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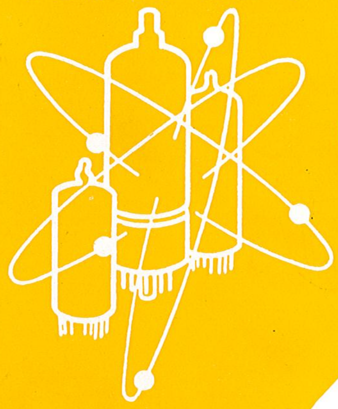

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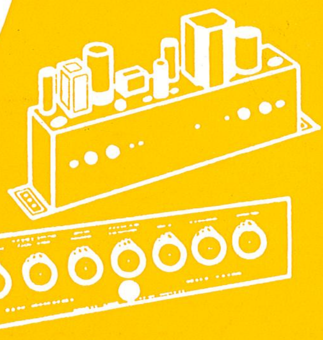

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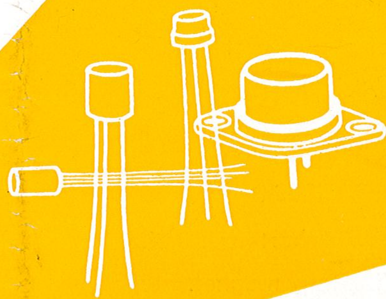

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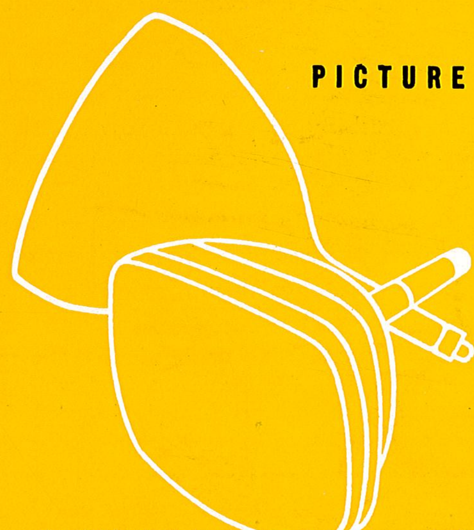

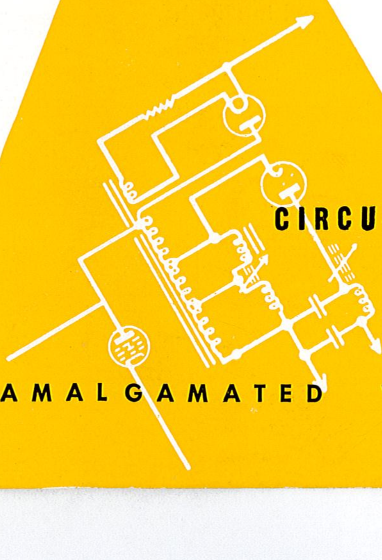

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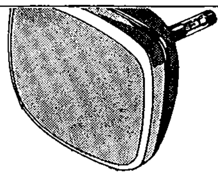

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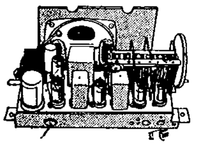

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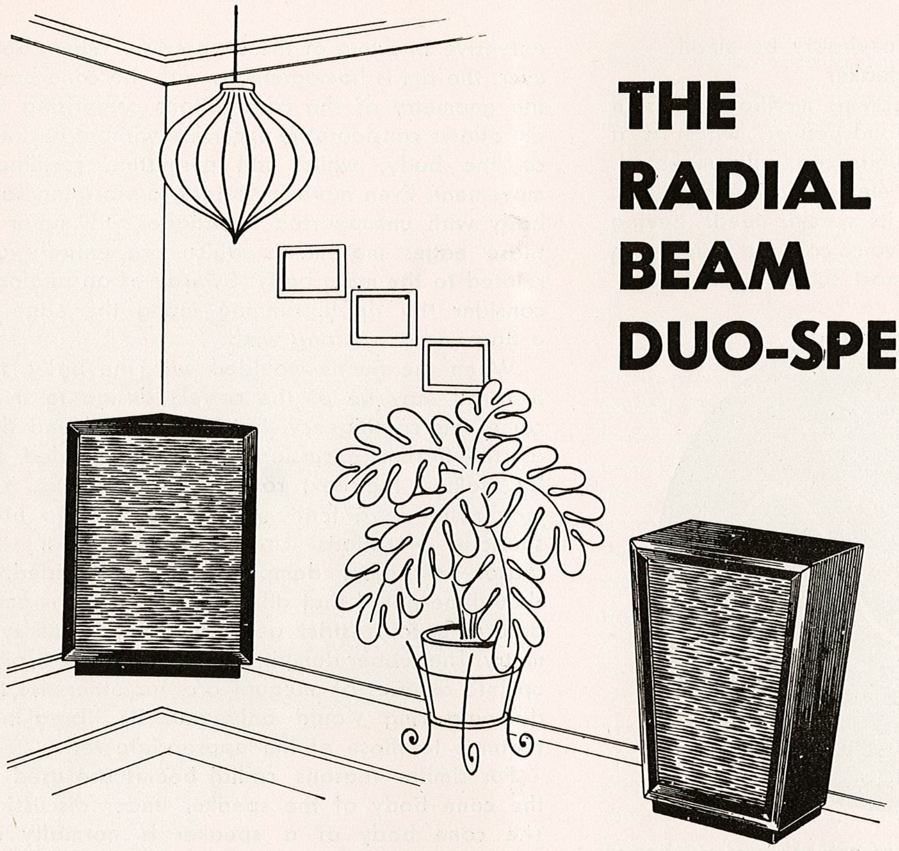


THE RADIAL BEAM DUO-SPEAKER

by A. McLean
(Components Development Section, A.W.A.)

A wide range sound system implies the need for great care in the design of each unit comprising the system. One of these units, the loudspeaker, poses very severe problems for the design engineer, mainly because of the large and rapid diaphragm movements which it must develop. Some account is given in this article of design procedures which should be followed if these problems are to be substantially overcome. The article also shows how the problems are dealt with in the case of the radial beam duo-speaker, and gives recommendations for using the speaker with a view to obtaining the optimum results.

Why Multiple Speakers?

It can be shown that it is impossible for every tone encountered in sound to be handled uniformly by a single diaphragm. The low frequency tones require for their development a moving element of large diameter and large mass, whilst the rim of the cone should be of such construction that no restriction is offered to the diaphragm movement. Even more important is the voice coil, which must impose the required force on the cone no matter how far the latter moves.

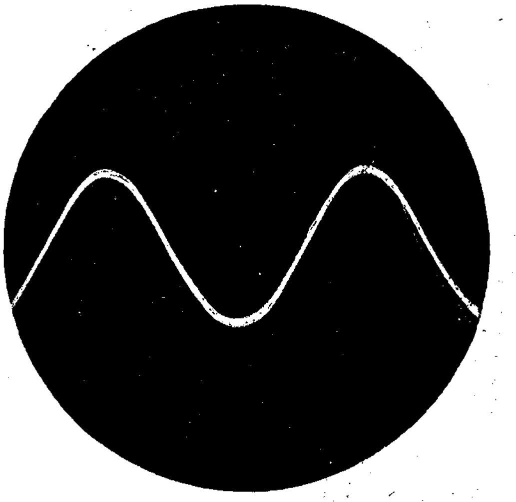
High frequency tones can be handled sucessfully only by a diaphragm of small diameter with the mass of the diaphragm and voice coil approaching zero. The diaphragm must be stiff, with a positive drive between the voice coil and the cone; even a fraction of an inch of paper former considerably reduces the efficacy of the system.

It is apparent from the foregoing that the two extremes cannot be met in a single unit. This is also true where two cones are used with a single voice coil. In such designs the mass is considerably increased over the permissible maximum for high frequency operation. Furthermore, where there are low and high frequency tones present at the same time, as when handling complex sounds, the high frequency element must be moved by the low frequency element at the same time as it is handling its own high frequency components. The resulting interaction can be responsible for some very undesirable effects. Again, it is not regarded as good practice to employ a thin vibrating surface with an unsupported edge; there will be times when that edge will vibrate in a random manner rather than in accordance with the forces applied.

There is a very marked tendency for high frequency tones to travel in a narrow ray directly along the axis of the cone movement. The larger the diameter of the diaphragm generating the tones the nearer does the ray approach a straight line, i.e., zero angle. When double cones are used, the diameter of the larger unit determines the angle, which must inevitably be small.

The Radial Beam Duo-Speaker

An answer to the problems mentioned lies in the radial beam dual loudspeaker, which is a system built upon two units coaxially mounted. There is not one common element in the two units. Each unit is designed for its specific needs, having its own magnetic system, voice coil and diaphragm in the type of housing most suited.



Unretouched photograph of actual response shown on CRO under following conditions:
Frequency: 40 c/s.
Amplifier: Modified Williamson with source impedance of 0.1 ohm.
Power in
Voice Coil: 15 Watts.
Enclosure: As drawing.
Microphone: Altec 21-B with pre-amplifier.
Oscillograph: Cossor 1049 Mk. III.

Note that this Duo-Speaker may be operated at exceedingly small input levels, up to a maximum of 20 Watts.

The low frequency unit has a solid cone, with a highly compliant rim of paper moulded homogeneously with the cone body to constitute the diaphragm. This system has a marked advantage over the cloth surround sometimes used, supposedly to improve the performance. It is one purpose of the rim to provide a radial stress to hold the edge of the cone always exactly concentric with the air gap in which the voice coil operates, even when the assembly moves backward and forward. If a cloth or chamois surround is used, it must be tight to provide the necessary constraint, but at the same time the cone body is required to move over considerable excursions.

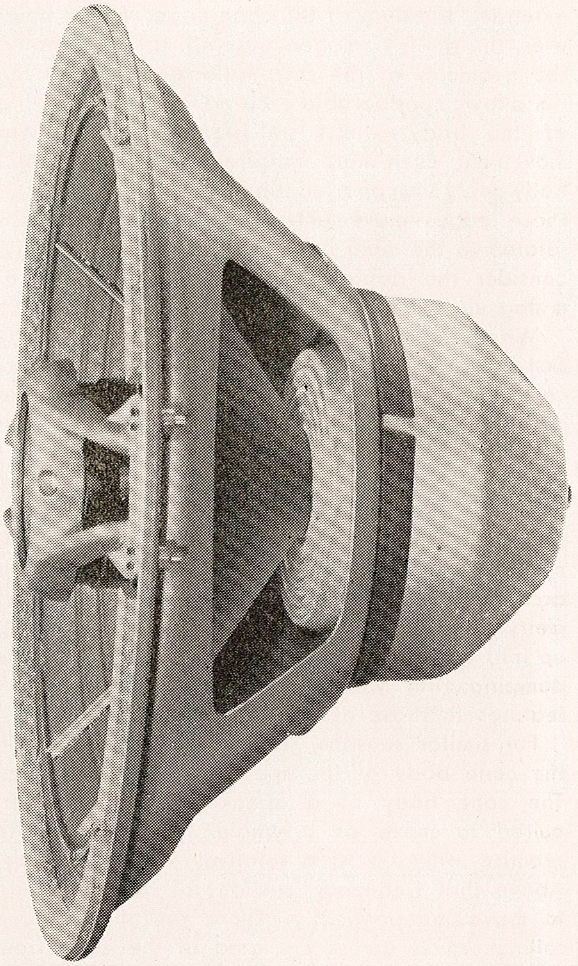
If the surround is tight in the stationary position, the amount of possible movement would be very limited, and most probably accompanied by extensive buckling of the cone edge. When, however, the rim is homogeneous with the cone body, the geometry of the corrugations comprising the rim allows considerable excursion without buckling of the body, whilst still permitting rectilinear movement. Even more important, a vibrating solid body with unsupported boundaries will suffer at those edges movements which are entirely unrelated to the main body. By way of an analogy, consider the ripple running along the edge of a flag under a strong wind.

When the rim is moulded with the body, the first roll may be of the correct design to overcome this contingency, but it may be found that a still further excursion must be provided for by making the next roll of larger radius. This may result in a tendency for this roll to have spurious vibrations circumferentially. For this reason, a rubber damping ring is provided. It should be noted that all spurious vibrations occur according to a strict geometric pattern of symmetry. The rubber damping ring is therefore broken up into a series of unequal arcs, as otherwise the damping ring would only add its "breaking" features to those of the appropriate roll.

For similar reasons, radial beams are used on the cone body of the speaker under discussion. The cone body of a speaker is normally required to move as a whole. This happens in practice only up to a relatively low frequency. Above that frequency, sections of the cone tend to move independently. There are thus formed rolling waves across the area of the cone from the voice coil to the rim, similar to ocean waves. The beams used in the construction of the cone strengthen the cone body radially and prevent the development of these waves. Here again there are unequal angles between the radial beams for the reason that the arcs of the rim damper are unequal, to prevent the symmetrical circumferential waves also existing at the same time.

These precautions all make for a highly successful "woofer", the purpose of which is to handle those peaks of power which the amplifier supplies. The lower the frequency being handled, the more difficult it is to obtain success, but so much has the design succeeded that, in very good enclosure conditions, the third harmonic distortion is down to 1% with 15W input at 45c/s. This represents almost the lowest note on the double bass as well as the bass drum, played with the full output of an amplifier with negligible distortion from the speaker.

The high frequency unit is barely 2.1/2 inches in diameter, being sufficiently small to provide a very wide angle of dispersion at high frequencies, and because the smaller "tweeter" is a self-contained unit, located in front of the large cone, the geometry of the former determines



mental disturbance experienced when a soprano sings the lower notes from the floor and the high ones from somewhere higher up the wall.

Whilst the two units comprising the dual speaker are referred to as being coaxially mounted, in actual fact, the "tweeter" is mounted off centre, so that a symmetrical cavity cannot exist between the large cone and the base of the "tweeter" unit.

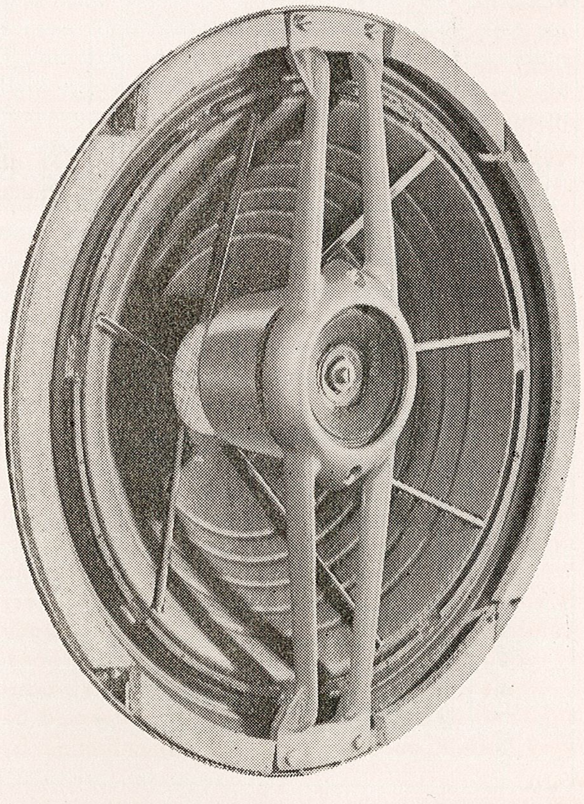
Cross-Over System

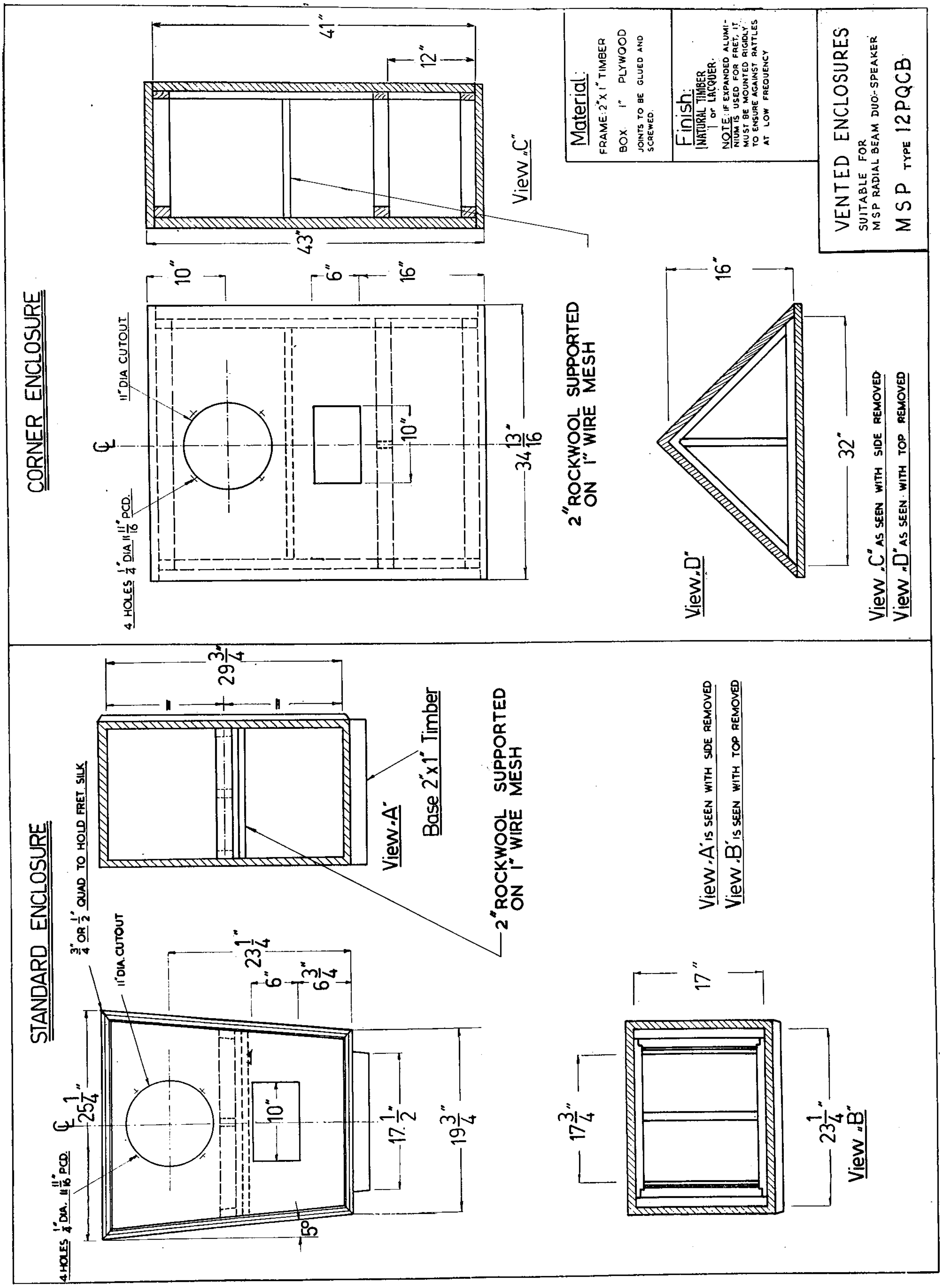
Since each element of the speaker is intended for a specific range of tones, some means must be provided to supply the respective units with their own frequencies. One method commonly used involves the use of cross-over networks or filters. These cause some loss of power, are costly, and are often unpredictable in their handling of complex musical tones. Whilst the low frequency notes must not enter the high frequency speaker or "tweeter", the converse is not so important. The "woofer" unit does not react to high frequency tones because of features provided in the design, and a built-in series capacitor excludes the low frequency tones from the "tweeter". Thus, very simply and without loss, the two units are made to handle the correct tones. The resulting combination has a well balanced output from its respective units, experiencing little in the way of peaks and dips in its frequency response, and with a very low figure of distortion.

the high frequency pattern. This means that a group of listeners hears the whole range of tones uniformly. A listener in the line of the speaker is not blasted by shrill "highs", whilst the others receive a character-less rendition. Some expensive combinations suffer from this fault and must point the "tweeter" toward the ceiling to obtain some dispersion.

The "tweeter" has its own magnetic circuit, which completely encloses the back of its cone. The high pressure waves from the large cone cannot therefore impinge upon the back of the "tweeter" cone, which moves only under its own influence. The high frequency cone has only about one-twentieth of the mass of its associate. It is rigidly held to its mountings and there are no free edges to ripple. Into this cone are built features to give it the required stiffness, but with no increase in mass.

The coaxial mounting of the two elements ensures that both of them provide sounds emanating from the same point. Whilst it can be shown that severe interference can result at some frequencies when speaker units are separated, it is of minor consequence when compared with the




CORNER ENCLOSURE
11" DIA CUTOUT
4 HOLES 1/4" DIA 11 11/16" PCD.
10"
6"
16"
41"
12"
43"
34 13/16"
2" ROCKWOOL SUPPORTED ON 1" WIRE MESH
View „C"
View „D"
32"
View „C" AS SEEN WITH SIDE REMOVED
View „D" AS SEEN WITH TOP REMOVED
Material:
FRAME: 2" x 1" TIMBER
BOX 1" PLYWOOD
JOINTS TO BE GLUED AND SCREWED.
Finish:
NATURAL TIMBER OR LACQUER.
NOTE: IF EXPANDED ALUMINIUM IS USED FOR FRET, IT MUST BE MOUNTED RIGIDLY TO ENSURE AGAINST RATTLES AT LOW FREQUENCY
VENTED ENCLOSURES
SUITABLE FOR MSP RADIAL BEAM DUO-SPEAKER
MSP TYPE 12PQCB
STANDARD ENCLOSURE
3/4" OR 1/2" QUAD TO HOLD FRET SILK
11" DIA. CUTOUT
4 HOLES 1/4" DIA. 11 11/16" PCD.
25 1/4"
23 1/4"
6"
6 3/4"
10"
17 1/2"
19 3/4"
5°
29 3/4"
View „A"
Base 2" x 1" Timber
2" ROCKWOOL SUPPORTED ON 1" WIRE MESH
17"
17 3/4"
23 1/4"
View „B"
View „A" IS SEEN WITH SIDE REMOVED
View „B" IS SEEN WITH TOP REMOVED

Specification of the Radial Beam Duo-Speaker

The specification provided by the manufacturer of this speaker is unusually detailed, and is given here in full. Not only does this illustrate the performance of this particular speaker, but also shows some of the relevant facts on which the prospective purchaser of a speaker should inform himself. It should be noted that the input to this speaker combination should be derived from a 15-ohm transformer secondary.

	12" Unit	2¼" Unit
Magnet:		
Flux Density	10,500 gausses	14,000 gausses
Total Flux	85,000 lines	26,000 lines
Weight	20 ounces	6.8 ounces
Material	Alcomax II	Alcomax II
Cone:		
Resonance	37-45 c/s	Not applicable
Projected Area	67 sq. ins.	3 sq. ins.
Voice Coil:		
Impedance	15Ω at 250 c/s	25Ω at 4,000 c/s
Diameter	1¼" Nominal	¾" Nominal
Housing:		
Diameter	12¼ inches	2 9/16 inches
Baffle Opening	11 inches	Not applicable
PCD of Mounting Holes	11¾ inches	Not applicable
Depth Overall	6" Max.	2¼" Max.
Weight (no transformer)	4¾lbs. Total weight with fittings 7½lbs.	2lbs.
Volume	100 cu. ins.	Not applicable
Electro Acoustics:		
Frequency Range	L.F. about 40 c/s H.F. 3,000 c/s	L.F. 3,000 c/s H.F. 15,000 c/s
Maximum rated output of amplifier per speaker	20 Watts	20 Watts above 3 kc/s
Coupling Capacitor	Nil	2 mfd wired in

Vented Enclosures

Some form of housing is essential if the low frequency notes are to be radiated into the room. The most elementary housing is a large flat board, or even the wall or ceiling of the room. The first does not allow the very low frequencies to be radiated, and the other alternatives do nothing towards suppressing the emphasis which any speaker experiences at its natural rate of vibration. For optimum results, some form of complete enclosure with control elements is essential.

This structure comprises a volume of enclosed air, and, associated with it, a port or vent, so that air from the inside flows through the vent when the diaphragm moves into the enclosure, and conversely may flow into the enclosure when the diaphragm moves outwards. There is, therefore, always a movement of a certain weight of air from and to an enclosed volume.

The weight of air constantly on the move is determined by the area of the vent and the thickness of the timber or other material of which the enclosure is constructed. This, in conjunction with the volume of air enclosed behind the diaphragm, is chosen so that its action tends to suppress the tendency of the speaker to vibrate very strongly at its natural rate of vibration. At the same time, the handling of low frequency tones below the natural resonant frequency is enhanced, giving lower frequency reproduction and lower distortion than that obtained with even an "infinite baffle".

As will be seen later, the corner construction offers advantages over that for use along a wall, and enables the room walls at the corner to be used for radiation purposes. The important points are the solidity of its construction and the absence of air leaks at the joints. Enclosure theory must be based upon surfaces which do not of themselves vibrate, nor may any air escape except through the controlling vent. Whilst the actual shape is not particularly important, for a practical approach an enclosed volume of 10,000 cubic inches in 7/8th-inch timber (after dressing) is recommended. Under these conditions, a rectangular-shaped port of 45 square inches is necessary.

It is strongly recommended that no tunnel be used; the opening in the front surface is sufficient. It is found that where a small enclosure is used, it is necessary to produce the movement of a large weight of air, and a tunnel must be incorporated. It can be demonstrated that the larger the volume of the enclosure the shorter the tunnel must become. In addition, the lower the resonance, the shorter the tunnel required. It follows therefore that there is a combination of enclosure volume and speaker resonance where the required mass of air may be obtained by providing only the necessary opening in the front of the enclosure. There are conditions where too small a weight of air is being moved, as well as the converse where too large a weight of air is being moved; both conditions introduce considerable distortion. Where a speaker manufacturer recommends a tunnel, one should be used, but it is distinctly unwise to use one where recommendations are against it.

The port should be close to the 11-inch speaker opening, but not so close as to leave a thin fillet of timber between the two openings. This fillet or bar may under certain conditions vibrate at its own natural frequency, thereby causing unwanted sounds. The 10,000 cubic inch volume should be arrived at after allowing for strengthening struts and the volume of the speaker unit itself.

If sound is established between two parallel surfaces, a condition is created known as standing waves; consider the character of sounds in a bathroom, where a "ringing" occurs. The same applies to three sets of parallel faces, as in the

Continued on page 68.

TAPE RECORDERS

PART 2

Non-Linear Recording Characteristic

Remembering the discussion of the hysteresis curves and the transfer characteristic curves, it can be seen that as the magnetizing force can swing in both directions from 0, that the transfer characteristic curve will also go in both directions from 0 as is shown in figure 13.

If an applied signal is recorded, as shown by one cycle of a sine wave, and projected to the transfer characteristic and then projected to the right, as is normally done with a signal on a vacuum valve characteristic curve, it is possible to plot the reproduced signal. It can be seen that because of the insteps of the two halves of the transfer characteristic curve, the signal is non-linear. Because of this non-linearity, it is impossible to make a satisfactory recording on tape without making some provision to use only the straight portion of the transfer characteristic curve or in some other way to flatten out the overall curve.

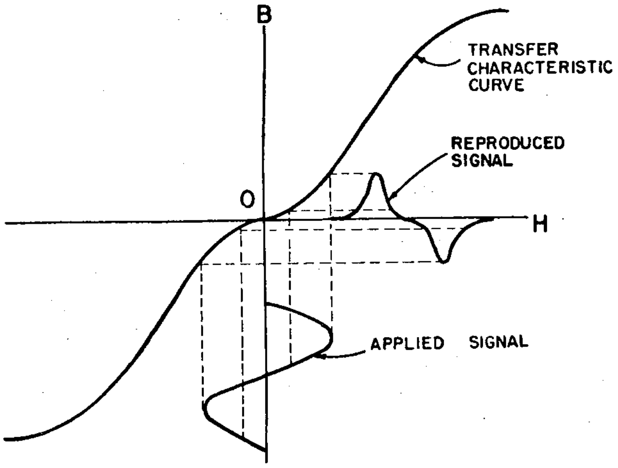


Fig. 13. The Non-linear Recording Characteristics.

DC Biasing

One method of eliminating distortion in tape recording is by the use of DC bias. In figure 13 it was seen that when the transfer characteristic curve based on the normal magnetizing curve was used, very serious distortion resulted because of non-linearity. If a small amount of bias is inserted so as to record only on the straight line portion of this previous curve, the level (due to extremely short length of the straight line portion) would be so low that a very poor signal-to-noise ratio would result, as well as a serious limit of dynamic range. If sufficient bias is used to shift the characteristic onto the side of the hysteresis curve this straight-line portion can be greatly increased. Here again, because remanence values are the values to be worked with, the transfer characteristic will be plotted from the hysteresis curve and it can be seen in figure 14

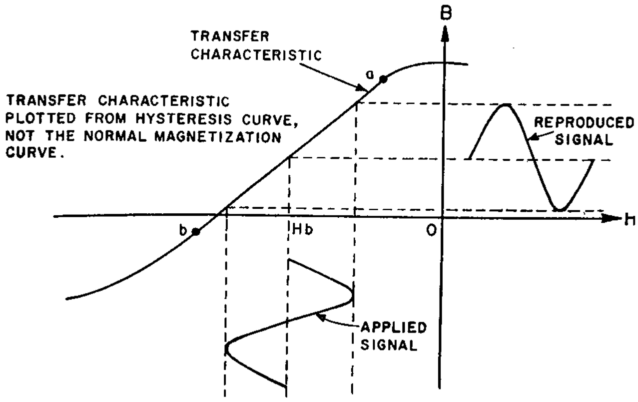


Fig. 14. The Effect of DC Biasing.

that a comparatively long straight-line section results, as shown by the line between (a) and (b). If a bias representing the distance OHb is chosen and the applied signal is inserted, using this bias as a neutral point, it is found that the reproduced signal will be reasonably free of distortion and of great enough sound amplitude so that signal-to-noise ratio is reasonably good. However, the DC bias value is extremely critical and if slight variation occurs, serious distortion can result. Also, the signal-to-noise ratio is not as good as other methods.

High Frequency Bias

A more satisfactory method of obtaining linearity is by the use of high frequency (supersonic) bias. This type of bias consists of a supersonic signal whose frequency should be at least five times the highest recorded audio frequency, and may be anywhere in the range from 30 kilocycles to about 80 kilocycles. As mentioned earlier, the understanding of minor hysteresis loops is important in the understanding of supersonic bias. In figure 15 the explanation is based on the minor hysteresis loops. It is fairly easy to understand the explanation based on the minor hysteresis loop theory when it is realised that the audio signal being used for recording is mixed with the supersonic bias signal. With no

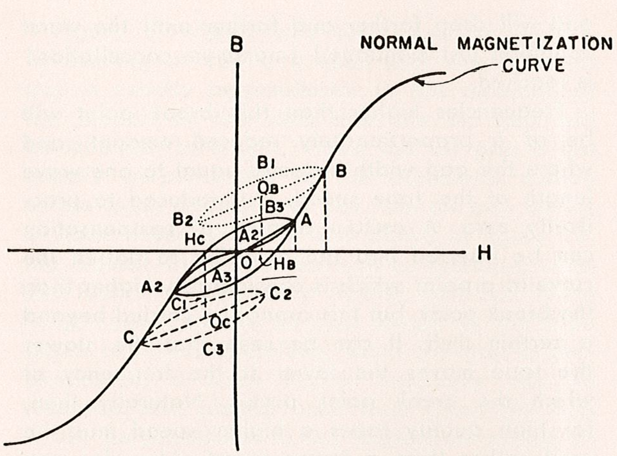


Fig. 15. High Frequency Bias in Tape Recording.

signal, the supersonic bias would create a minor hysteresis loop (the magnetizing force would go from 0 through the positive half of the cycle, back to 0 and through the negative half of the cycle) as shown by the loop represented by A, A_1, A_2, A_3. When the positive half of the audio signal is considered, the average magnetizing force will be increased from 0 to Hb and the minor hysteresis loop will be automatically moved up to the position shown by B, B_1 B_2, and B_3. During the negative half of the audio signal the opposite occurs and the minor hysteresis loop will be moved down on the other half of the characteristic to the points represented by C, C_1, C_2, and C_3. Therefore, the average, or centre point, of the hysteresis lop swings up and down, depending upon the audio signal following a straight line characteristic, in effect straightening the characteristic, or making it linear.

In figure 16 high frequency bias is considered from another angle. Here the transfer characteristic rather than the normal magnetization curve is used because the interest is in the remanent values when considering the problem from this viewpoint. Again, the high frequency bias and

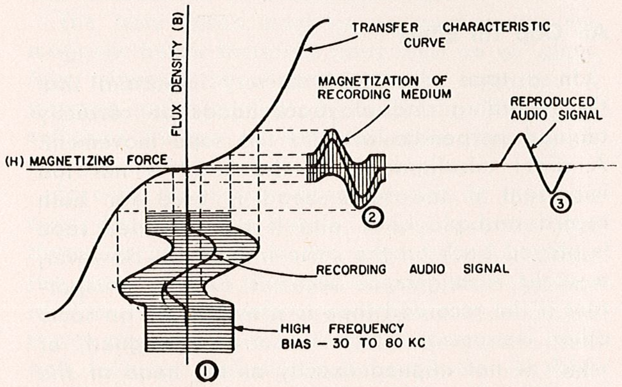


Fig. 16. The Effect of High Frequency Bias.

the audio signal are mixed, producing a wave shown in figure 16 (1), an envelope composed of the two signals involved. This is projected vertically to the transfer characteristic then re-projected horizontally to show the magnetization of the recording medium, figure 16 (2). Here it is seen that the side of the envelope has been seriously distorted. The positive half of the upper edge of the envelope is reasonably correct, but the lower edge of the envelope has been highly distorted. The opposite condition exists with the negative side of the envelope. This is the signal that will be recorded on the tape. The signal created by the average voltage of the envelope, is a reasonably accurate reproduction of the original audio signal and is indicated in figure 16 (3). For example, when the recorded signal shown in (1) is reproduced on tape, the recording will actually result in the audio signal as shown at (3).

This reproduced signal will contain a slight amount of distortion, but proper choice of the magnetic field and bias currents reduces the distortion to a fairly low value. The signal-to-noise ratio will be extremely good because of the length of the transfer characteristic over which linearity, by use of the high frequency bias, is obtained.

Erasing

Erasing can be accomplished by permanent magnets, by DC, or AC heads. The major requirement is that the head should be capable of creating a magnetizing force strong enough to saturate the medium in the required direction, in the case of DC or permanent magnetic erasure.

Referring to the hysteresis curve, in order to obtain complete erasure it will be necessary to magnetize the medium in the opposite direction from the original signal to an amount equal or greater than the original signal (actually it is magnetized to saturation) and then returned to an amount which would give a 0 remanent value. Going to saturation does the erasing, but if left there, high noise will be left on the top. This is most simply done by positioning the head so that the above requirements are met as the tape passes over the erasing head. Figure 17 shows just how this is done in the case of a bar magnet. The bar magnet has one pole against the tape so that the field is great enough through the tape to cause sufficient magnetization to saturate in the opposite direction from the recording. As a point on the tape (indicated by "A") reaches the north pole of the bar magnet, moving as shown by the arrow, the medium is brought to saturation as shown by A' on the hysteresis curve. As the tape continues to move, this point shifts from "A" to "C" where the effect of the south pole has changed the induction from A' to a point represented by C' on the hysteresis curve. As the tape continues to move so that the point moves on to "D" and reaches the area being unaffected by the magnet, the induction changes from C' to D' on the hysteresis curve and brings the remanence induction to 0.

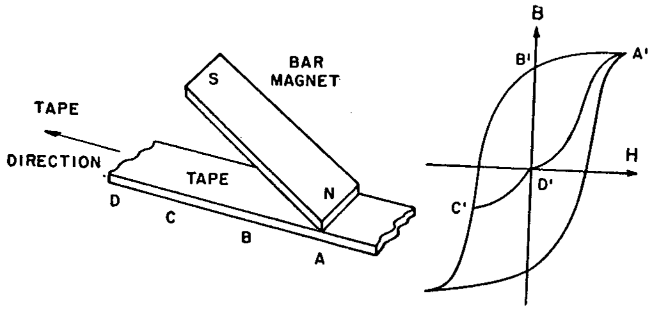


Fig. 17. Erasing the Tape.

Frequency Response

When recorded signals of equal amplitudes but different frequencies are reproduced by a magnetic pick-up head from tape, the outputs at the different frequencies will not be equal but will vary depending on the frequencies; the higher the frequency, the higher the output. The reason for this is that the voltage induced by a changing magnetic field is proportional to the rate of change of the field. Therefore, is a 100 cycle per second frequency gives a certain output from a tape that has been recorded in a field which is equal at all frequencies, a 200 cycle per second frequency will reproduce through the magnetic head with double the output of the 100 cycle frequency. Therefore, when this response is plotted as shown in figure 18, the slope of the curve will be 6 decibels per octave. In other words, the frequency of musical notes doubles for each octave. A 6 decibel increase in output means that the output has been doubled.

This is true only at the low frequencies. At a certain frequency, a break occurs, so beyond the break frequency the response curve begins to drop downward. This is caused by two factors. (1) A combination of the gap length and the speed at which the tape is moving and (2) Self demagnetization of the tape.

It can be seen from figure 18 that when the frequency is such that a point on the tape moves one complete cycle in the distance equal to the gap length at the speed the tape is travelling, that the voltage generated by the positive and the negative portion of the cycle will cancel.

This is the worst condition. The break actually begins at the point where one-half wave length is equal to the gap length at the tape speed used and will drop farther and farther until the worst condition just mentioned (maximum cancellation) is reached.

Frequencies higher than this break point will be at a proportionately reduced amount, and where the gap width becomes equal to one wave length at the tape speed, it is reduced to practically zero. A certain amount of compensation can be inserted into the amplifier to flatten the curve to a point which is considerably higher than the break point, but this cannot be carried beyond a certain limit. It can be seen that the slower the tape moves the lower is the frequency at which the break point occurs. Naturally then, for high quality tapes a higher speed must be used rather than a lower speed. Also, for any fixed tape speed, the shorter the air gap, the higher will be the top frequency that can be recorded. The slope above the break point is made steeper by self demagnetization of the tape, which causes an additional break to occur at a travel length equal to 1/10 the air gap length. When a magnet is wider than it is long, it tends to demagnetize itself because of the lower coercive force. This is equivalent to tape recorded with very short wave lengths.

In order to obtain flat response from the output of the tape playback equipment, it is, of course, necessary to equalize the playback amplifier characteristic to roughly the opposite characteristic of the response curve just discussed.

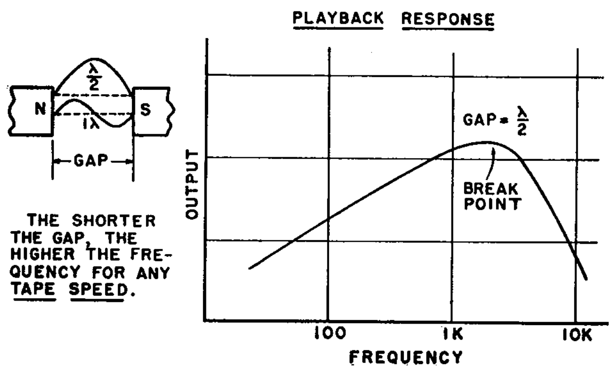


Fig. 18. The Effect of Air-gap Length.

Air Gap Tilt Effect

In a tape recorder it is very important that the recording and playback heads be correctly aligned perpendicularly to the tape movement. A slight misalignment of the head is not too important if the same head is used for both record and playback and if the recorded tape is played back on the same instrument. However, a slight misalignment becomes extremely important if the recorded tape is played back on some other instrument which is correctly aligned, or which is not aligned exactly as the head of the recording instrument.

Figure 19 shows why this condition is true. By looking at (a) it is seen that when the air gap is exactly perpendicular to the direction of the motion of the tape that the air gap will be minimum in length. When the air gap is not exactly perpendicular to the horizontal motion of the tape, as shown in (b), the air gap covers a much wider area. As was shown in figure 18, the highest frequency that can be recorded without loss is a frequency having one-half wave length equal to the air gap length at the tape speed involved. Therefore, when the gap is perpendicular, a much higher frequency can be recorded and played back than when the gap is not perpendicular to the horizontal motion of the tape.

Naturally, if the head becomes misaligned the high frequencies drop off very rapidly.

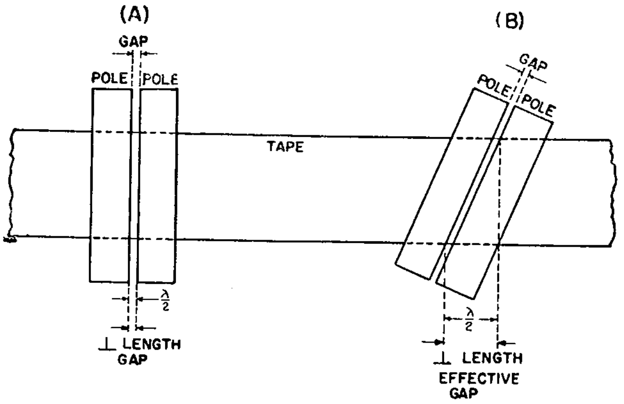


Fig. 19. Air-gap Tilt Effect.

TRANSPORT MECHANISM

A tape recorder has mechanical considerations similar in many ways to those of a record player. The motion must be of correct speed and constant speed with no irregularities or binds anywhere in the mechanism. The motors must be heavy enough to pull considerably more than the maximum load of the unit. The main drive shaft of the unit (in the case of the tape recorder — the capstan) must be loaded with a fly wheel and must be set in smooth bearings.

The tape speed must be constant across the magnetic heads therefore there must be an absolute minimum of slippage at the capstan. A pressure roller against the capstan will supply sufficient friction to minimize tape slippage at this point.

In order to insure smooth motion of the tape over the magnetic heads, it is important that there be no slack in the tape between either the load reel or the take-up reel and the rest of the tape transport mechanism. In order to insure no slack it is important that smooth drive and take-up mechanisms be used for the reel shafts.

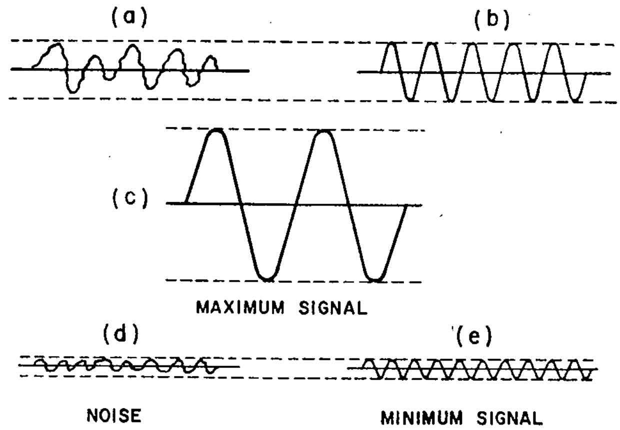


Fig. 20. Noise Level Considerations.

Tape threading methods vary widely. One, such as the TR-1 used in the RCA Victor Model 6HF1 high fidelity instrument and shown in figure 21, has two idlers to assist in keeping out any tape slack. Other instruments have different types of mechanisms. The transport mechanism must be extremely free of wows and flutter.

Reel Drive

The tape transport mechanism must allow extremely smooth tape movement past the magnetic heads with no slack at the reels. In order to do this, the load reel must gradually speed up as the take-up slows down. This, of course, must be accomplished as the tape moves at an absolutely constant speed past the heads.

There are three types of reel drives in general tape recorder use:

(a) The spring belt drive is one of the most common types. The spring belt connects the drive to both the take-up and load reels and the pulleys are of such size that the take-up will be driven at a slightly higher speed than will be necessary at the innermost edge of its diameter. The stretch in the spring allows slippage to occur so that the reel can rotate at only the speed allowed by the movement of the tape over the capstan. The drive to the load reel is usually released from the main drive and the slipping of the belt acts as a drag because the drive pulley is anchored.

(b) Friction clutch drive of the reels — exactly the same thing happens as has just been explained for the spring belt except that in this case the slippage is supplied through a standard clutch mechanism where a leather washer between two discs allows for the slippage.

(c) Motor drag drive — this type of reel drive uses a separate torque-type induction motor on each reel shaft. The two motors are connected so that the one driving the reel being used for take-up, runs as fast as the tape speed through the capstan will allow. The other motor acting as drag on the load reel tends to run in the reverse direction at a reduced voltage which depends on the speed at which the take-up reel is operating. Therefore, as the take-up reel runs slower, the motor holding back the load reel tends to pull harder increasing the drag as the load reel speeds up.

Controls

The controls of a tape recorder must be, of course, simple and easy to operate if the recorder is going to meet with the requirements of the public. Some of the most important requirements are as follows:

1. The mechanism must start instantly without a variation of speed during the starting period, since this will inject wows into the first few inches of recording.

2. The mechanism must stop instantly with smooth braking of both the take-up and load reels, otherwise tape breakages may become an important item.

3. The instrument must have fast forward and fast reverse speed with quick changeover from one direction to the other. This is to assist in the ease of editing and rewinding tape.

4. When more than one tape speed is utilized, there must be an accurate, definite changeover from one to the other.

5. Facilities should be provided so that the instrument can be controlled remotely when desired.

Noise Level

The lowest recorded signal level is normally determined by the tape and playback amplifier noise. Some noise may be generated in the instrument itself, and some may be picked up from the room in which the recording is being made. That being picked up in the room is partially controllable. It is important to make recordings in a room having qualities that will tend to minimize reflected noises, and of course, people in the room must be careful to make as little noise as possible (other than that desired to be recorded).

Noises from the machine and its electronic circuits must be at a minimum. Figure 20 shows that when a noise has an intensity as in (a) the recording level for the audio signal must be at least that same level in order to be heard above the noise. The lower the noise level as in (d) the lower will be the signal that can be recorded and still be heard clearly as shown in (e).

Figure 20 (c) shows a maximum sound signal that might be recorded in an instrument as compared with a minimum signal such as (b) or (e). The maximum signal that can be recorded on any instrument is controlled entirely by the point of overload of the system. By looking at signal (e), which is very small as compared with signal (c), it can be seen that the dynamic range (or the volume range), between (c) and (e) and/or (d) will be much greater than the dynamic range between (b) and (c) and/or (a). Therefore, it can be said that as compared to (c), in the case of (d) there is a much better signal-to-noise ratio than in the case of (a).

It is necessary, in order to obtain the most flexibitlity and the best quality from a tape recorder, to keep this signal-to-noise ratio as great as possible.

Noise directly concerned with the instrument itself can come from several sources. These are:

1. Flaws in the magnetic material.
2. Variation in the sound track cross-sectional area.
3. Variations in the contact between the head and the tape. (This is one of the major reasons that the tape tension must be kept constant across the recording and playback heads.)

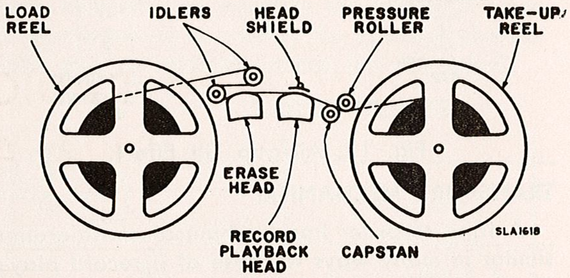


Fig. 21. The Tape Transport Mechanism.

TAPE CHARACTERISTICS

Magnetic recording as discussed here is considered as applying entirely to tape. As all information which it is wished to reproduce must first be recorded on the tape, it follows that the characteristics of the tape are extremely important. The major characteristics are discussed here. They are:

1. Coercivity of a good recording tape should be between 200 and 500 oersteds. As has been discussed, coercivity is the force with which a magnetic material resists demagnetization. It can be seen that a higher value of coercivity would actually be better for the recording of high frequencies, but that it would become extremely difficult or even impossible to erase with any of our present erasing heads. Therefore, the range between the two values given seems to be the best practical value.

2. Remanence must be as high as possible. Remanence is the induction remaining in a ferromagnetic material after being subjected to a magnetic field. Therefore, the higher the remanence, the higher will be the recorded level on the tape.

3. The sound track must have uniform cross-sectional dimensions. The tape should have extremely smooth surfaces. The ferromagnetic material, of course, must be extremely smooth on the surface where it contacts the heads. If the base is not smooth the ferromagnetic material cross-sectional area will vary and the levels of both recording and noise may vary appreciably.

4. The tape must have high tensile strength so that it can be handled normally without breakage or damage.

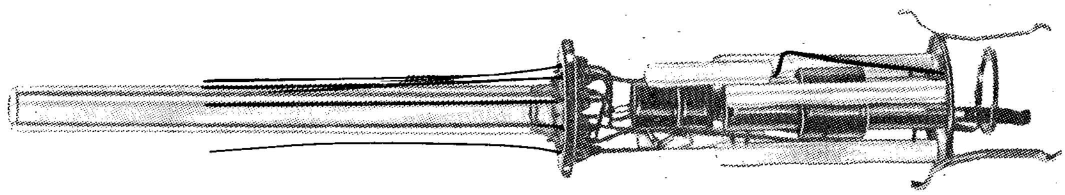
5. The tape should be mechanically limp in order to facilitate winding. If this condition does not exist, the tape can become very springy and hard to roll without becoming tangled.

6. The tape should be easy to splice. One of the big advantages of the tape recording is the practicability of editing.

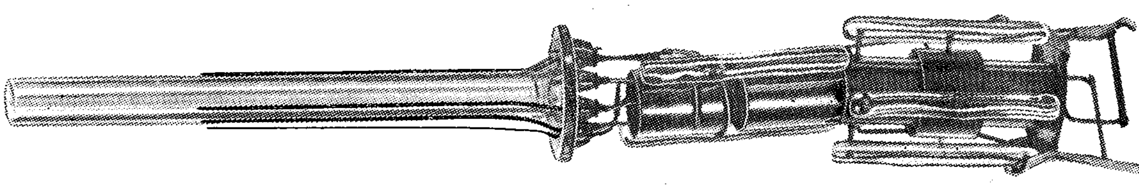
7. The base and the magnetic material of the tape must have both dimensional stability and uniformity. Magnetic material must also have magnetic stability with uniformity.

8. The magnetic material should not transfer recording from one layer to another on a roll by the contact of winding. If it does, the recording on one layer will be heard at a lower volume mixed with the recording on the next layer in either direction. This is not desirable.

9. Cost and the physical volume of tape per unit of recording time should be small. Again, one of the important items in tape work is the low cost, which makes it practical and advantageous to use over most other methods of recording sound.



NEW AWV RADIOTRON PICTURE TUBES 17BJP4 AND 21CBP4-A



Two new Radiotron picture tubes, the 17BJP4 and the 21CBP4A, have been added to the AWV Radiotron range. These tubes are suited for applications where a shorter overall length of picture tube is desirable. Both tubes use a straight electron gun assembly, which results in a reduction of overall length of over one inch in the 17BJP4 as compared with the 17AVP4A, and of two inches in the 21CBP4A as compared with the 21ALP4A.

The use of the straight electron gun assembly eliminates the need for an ion trap magnet. This results in a saving of time in setting up the tube in the receiver, as it is necessary only to adjust the brightness control to obtain a picture, which can then be centred and focused in the normal way. The method of centring the picture remains the same as for the bent-gun tubes. The absence of the ion trap removes the possibility of misadjustment of the ion trap magnet causing failure to get a picture when setting up the tube, and also causing possible burning of electron gun apertures by deflection of the electron beam against the electrode structure.

Although the ion trap is eliminated in these two new tubes, extreme care is taken in manufacture to provide complete protection against ion burn and ensure a long and satisfactory life in service. Additional protection is given to the phosphor screen by approximately doubling the thickness of the screen aluminizing. Although an electrostatically-focused gun and electromagnetic deflection naturally focus the ions to the centre of the screen, the aluminium thickness is closely controlled over the entire screen area.

RADIOTRON 17BJP4 PICTURE TUBE

The Radiotron 17BJP4 has a 16⅝" envelope diagonal and an overall length of only 14⅝". It features a new electron gun of the "straight" type, designed to minimise deflection distortion. This gun permits a short neck — only 5½" long, and eliminates the need for an ion-trap magnet.

The Radiotron 17BJP4 utilises low-voltage electrostatic focus and employs a 90° deflection angle. It has a spherical filterglass faceplate, an aluminized screen 14-5/16" x 11-1/8" with slightly curved sides and rounded corners, and a minimum projected screen area of 149 square inches. In addition, the 17BJP4 has an external conductive bulb coating which provides a capacitance value ranging between 1000 and 1500 μμF.

GENERAL

Heater Voltage	6.3 volts
Heater Current	0.6 amp.
Direct interelectrode Capacitance:	
Grid No. 1 to all other electrodes	6 μμF
Cathode to all other electrodes	5 μμF
External conductive coating to ultor	1,500 max. μμF; 1,000 min. μμF
Faceplate, Spherical	Filterglass
Light transmission (Approx.)	74%
Phospor	P4-Sulphide Type .... aluminized
Fluorescence	White
Phosphorescence	White
Persistance	Short
Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angles (Approx.)	
Diagonal	90°
Horizontal	85°
Vertical	68°
Electron Gun:	
Requires no external Ion-trap Magnet	

Tube Dimensions:		
Overall Length	14-5/8"	± 3/8"
Greatest Width	15-3/8"	± 1/8"
Greatest Height	12-9/32"	± 1/8"
Diagonal	16-5/8"	± 1/8"
Neck Length	5-1/2"	± 3/16"

Screen Dimensions (Minimum):	
Greatest Width	14-5/16"
Greatest Height	11-1/8"
Diagonal	15-9/16"
Projected area	149 sq. in.
Weight (Approx.)	15 lbs.
Mounting position	Any
Cap	Recessed small cavity (JETEC No. J1-21)
Bulb	J-133
Base	Small-Shell Duodecal 6-pin (JETEC No. B6-63)

SOCKET CONNECTIONS

As for Radiotron 21CBP4-A, see page 65

GRID-DRIVE SERVICE

Grid drive is the operating condition in which the video signal varies the grid-No. 1 potential with respect to cathode.

(Unless otherwise specified, voltage values are positive with respect to Grid No. 1)

MAXIMUM RATINGS, Design-Centre Values:

ULTOR VOLTAGE	16,000 volts
GRID No. 4 VOLTAGE	
Positive Value	1,000 volts
Negative Value	500 volts
GRID No. 2 VOLTAGE	500 volts
GRID No. 1 VOLTAGE	
Negative peak value	200 volts
Negative bias value	140 volts
Positive bias value	0 volts
Positive peak value	2 volts
PEAK HEATER-CATHODE VOLTAGE	
Heater negative with respect to cathode:	
During equipment warm-up period not exceeding 15 seconds	410 volts
After equipment warm-up period	180 volts
Heater positive with respect to cathode	180 volts

EQUIPMENT DESIGN RANGES:

(With any ultor voltage (E_{c5k}) between 12,000* and 16,000 volts and Grid No. 2 voltage (E_{c2k}) between 200 and 500 volts)

Grid No. 4 Voltage for Focus	— 0.4% to + 2.2% of E_{c5k}	volts
Grid No. 1 Voltage or Visual Extinction of Focused Raster	— 9.3% to — 24% of E_{c2k}	volts
Grid No. 1 Video Drive from Raster Cut-off (Black Level): White-Level Value (Peak Positive)	9.3% to 24% of E_{c2k}	volts
Grid No. 4 Current	— 25 to + 25	μamp
Grid No. 2 Current	— 15 to + 15	μamp
Field Strength of Adjustable Centring Magnet	0 to 8	oersteds

EXAMPLES OF USE OF DESIGN RANGES:

With Ultor Voltage of	14000	16000	volts
And Grid No. 2 Voltage of	300	300	volts
Grid No. 4 Voltage for focus	— 55 to + 300	— 65 to + 350	volts
Grid No. 1 Voltage for Visual Extinction of Focused Raster	— 28 to — 72	— 28 to — 72	volts
Grid No. 1 Video Drive from Raster Cut-off (Black Level): White-Level Value (Peak Positive)	28 to 72	28 to 72	volts

MAXIMUM CIRCUIT VALUE:

Grid No. 1 Circuit Resistance .... 1.5 megohms

CATHODE-DRIVE SERVICE

Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to Grid No. 1 and the other electrodes.

(Unless otherwise specified, voltage values are positive with respect to Grid No. 1)

MAXIMUM RATINGS, Design-Centre Values:

ULTOR TO GRID No. 1 VOLTAGE	16,000 volts
GRID No. 4 TO GRID No. 1 VOLTAGE:	
Positive Value	1,000 volts
Negative Value	500 volts
GRID No. 2 TO GRID No. 1 VOLTAGE	640 volts
GRID No. 2 TO CATHODE VOLTAGE	500 volts
CATHODE TO GRID No. 1 VOLTAGE:	
Positive Peak Value	200 volts
Positive Bias Value	140 volts
Negative Bias Value	0 volts
Negative Peak Value	2 volts
PEAK HEATER-CATHODE VOLTAGE	
Heater Negative with respect to Cathode:	
During equipment warm-up period not exceeding 15 seconds	410 volts
After equipment warm-up period	180 volts
Heater positive with respect to Cathode	180 volts

EQUIPMENT DESIGN RANGES:

(With any ultor to grid No. 1 Voltage (E_{c5g1}) between 12,000* and 16,000 volts and Grid No. 2 to Grid No. 1 Voltage (E_{c2g1}) between 220 and 640 volts)

Grid No. 4 to Grid No. 1 Voltage for focus	0% to 2.6% of E_{c5g1}	volts
Cathode to Grid No. 1 Voltage for Visual Extinction of focused Raster	8.5% to 19.4% of E_{c2g1}	volts
Cathode to Grid No. 1 Video Drive from Raster Cut-off (Black Level): White-Level Value (Peak Negative):	— 8.5% to — 19.4% of E_{c2g1}	volts
Grid No. 4 Current	— 25 to + 25	μamp
Grid No. 2 Current	— 15 to + 15	μamp
Field Strength of Adjustable Centring Magnet	0 to 8	oersteds

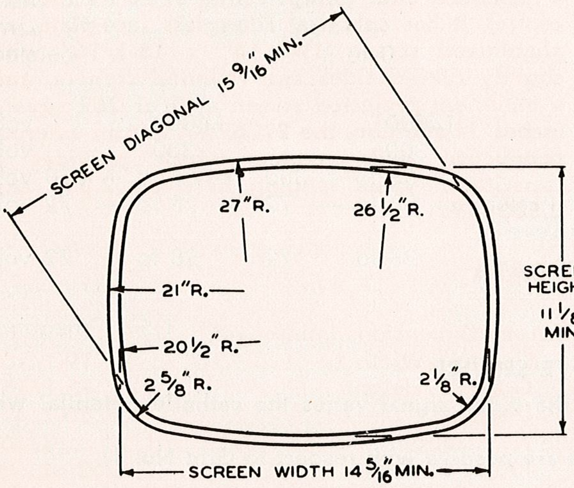
EXAMPLES OF USE OF DESIGN RANGES:

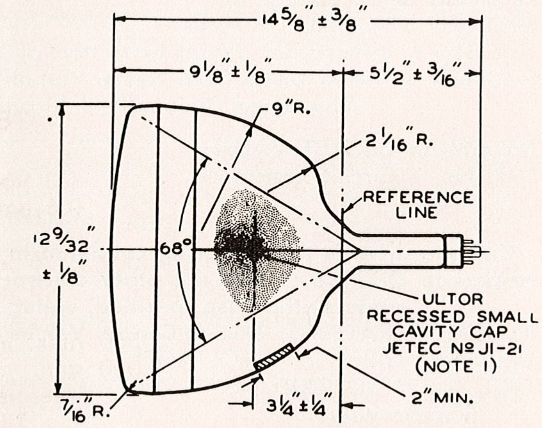
With Ultor to Grid No. 1 Voltage of	14000	16000	volts
And Grid No. 2 to Grid No. 1 Voltage of	300	300	volts
Grid No. 4 to Grid No. 1 Voltage for focus	0 to 365	0 to 415	volts
Cathode to Grid No. 1 Voltage for Visual Extinction of Focused Raster	28 to 60	28 to 60	volts
Cathode to Grid No. 1 Video Drive from Raster Cut-off (Black Level): White-Level Value	— 28 to — 60	— 28 to — 60	volts

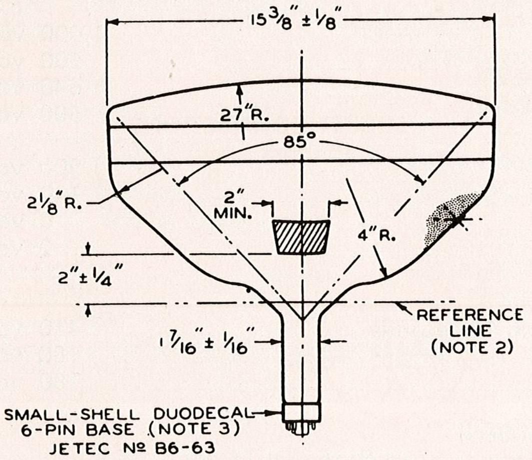
MAXIMUM CIRCUIT VALUE:

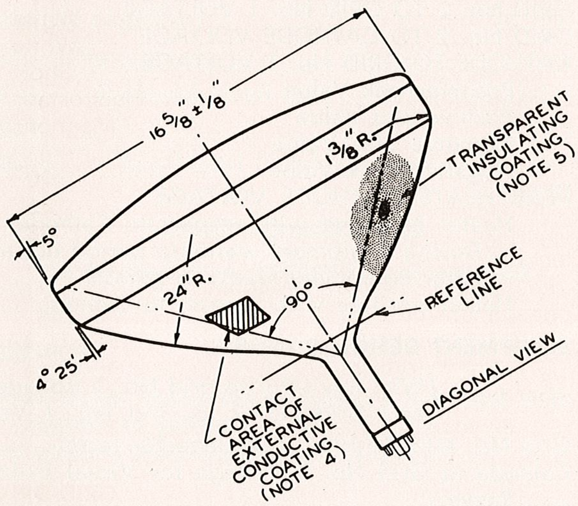
Grid No. 1 Circuit Resistance .... 1.5 megohms

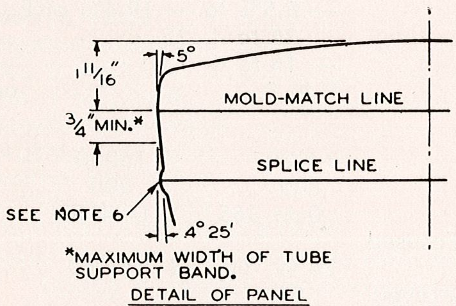
* Brilliance and definition decrease with decreasing ultor voltages or ultor-to-grid No. 1 voltage. In general, the ultor voltage or ultor-to-grid No. 1 voltage should not be less than 12,000 volts.











NOTES:

For Notes, see page 68, but read the diameter given in Note 3 as $2\frac{3}{4}$" when applying to the 17BJP4.

RADIOTRON 21CBP4-A PICTURE TUBE

The Radiotron 21CBP4-A has a 21$\frac{3}{8}$" envelope diagonal and an overall length of only 18". It features a new electron gun of the "straight" type designed to minimize deflection distortion. This gun permits a short neck — only 5$\frac{1}{2}$" long, and eliminates the need for an ion-trap magnet.

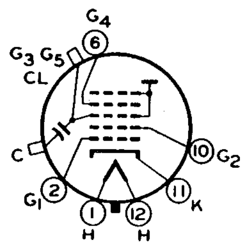
The 21CBP4-A utilizes low-voltage electrostatic focus, employs a 90° deflection angle, and has a maximum ultor-voltage rating of 20 KV (design centre). It has spherical Filterglass face-plate, an aluminized screen 19-1/16" x 15-1/16" with slightly curved sides and rounded corners, and a minimum projected screen area of 262 square inches. In addition, the 21CBP4-A has an external conductive bulb coating which provides a capacitance value ranging between 2,000 and 2,500 $\mu\mu$F.

GENERAL DATA

Heater Voltage	6.3 volts
Heater Current	0.6 amp.
Direct Interelectrode Capacitances:	
Grid No. 1 to all other electrodes	6 $\mu\mu$F
Cathode to all other electrodes	5 $\mu\mu$F
External conductive coating to ultor	2,500 max. $\mu\mu$F; 2,000 min. $\mu\mu$F
Faceplate, Spherical	Filterglass
Light transmission (approx.)	74%
Phosphor, metal-backed	P4 Sulphide Type
Fluorescence	White
Phosphorescence	White
Persistance	Short
Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angles (approx.):	
Diagonal	90°
Horizontal	85°
Vertical	68°
Electron Gun:	
Requires No Ion-Trap Magnet	
Tube Dimensions:	
Overall Length	18" ± $\frac{3}{8}$"
Greatest Width	20$\frac{1}{4}$" ± $\frac{1}{8}$"
Greatest Height	16$\frac{3}{8}$" ± $\frac{1}{8}$"
Diagonal	21$\frac{3}{8}$" ± $\frac{1}{8}$"

Screen Dimensions (minimum):	
Greatest Width	19-1/16"
Greatest Height	15-1/16"
Diagonal	20-1/4"
Neck Length	5-1/2" ± 3/16"
Projected area	262 sq. in.
Cap — Recessed small cavity (JETEC No. J1-21)	
Bulb	J171
Base — Small-Shell Duodecal 6-pin (JETEC No. B6-63)	
Weight (approx.)	24 lbs.
Mounting Position	Any

SOCKET CONNECTIONS
(bottom view)



Pin 1—Heater
Pin 2—Grid No. 1
Pin 6—Grid No. 4
Pin 10—Grid No. 2
Pin 11—Cathode
Pin 12—Heater
Cap — Ultor (Grid No. 3, Grid No. 5, Collector)
C—External Conductive Coating.

GRID-DRIVE SERVICE

Grid drive is the operating condition in which the video signal varies the grid-No. 1 potential with respect to cathode.

(Unless otherwise specified, voltage values are positive with respect to cathode.)

MAXIMUM RATINGS, Design-Centre Values:

ULTOR VOLTAGE	20,000 volts
GRID No. 4 VOLTAGE:	
Positive value	1,000 volts
Negative value	500 volts
GRID No. 2 VOLTAGE	500 volts
GRID No. 1 VOLTAGE	
Negative peak value	200 volts
Negative bias value	140 volts
Positive bias value	0 volts
Positive peak value	2 volts

PEAK HEATER-CATHODE VOLTAGE:

Heater negative with respect to cathode:	
During equipment warm-up period not exceeding 15 seconds	410 volts
After equipment warm-up period	180 volts
Heater positive with respect to cathode	180 volts

EQUIPMENT DESIGN RANGES:

(With any Ultor Voltage (E_{c5k}) between 12,000‡ and 20,000 volts and Grid No. 2 Voltage (E_{c2k}) between 200 and 500 volts)

Grid No. 4 Voltage for Focus*	0 to 450	
Grid No. 1 Voltage for Visual Extinction of Focused Raster	— 9.3% to — 24% of E_{c2k}	volts
Grid No. 1 Video Drive from Raster Cut-off (Black Level): White Level Drive (Peak Positive)	9.3% to 24% of E_{c2k}	volts
Grid No. 4 Current	— 25 to + 25	μamp
Grid No. 2 Current	— 15 to + 15	μamp
Field Strength of Adjustable Centring Magnet	0 to 8	oersteds

EXAMPLES OF DESIGN RANGES:

With Ultor Voltage of	16000	18000	volts
And Grid No. 2 Voltage of	300	400	volts
Grid No. 4 Voltage for Focus	0 — 450	0 — 450	volts
Grid No. 1 Voltage for Visual Extinction of Focused Raster	— 28 to — 72	— 35 to — 94	volts
Grid No. 1 Video Drive from Raster Cut-off (Black Level): White-Level Drive (Peak Positive)	28 to 72	35 to 94	volts
MAXIMUM CIRCUIT VALUE:			
Grid No. 1 Circuit Resistance		1.5	megohms

CATHODE-DRIVE SERVICE

Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to Grid No. 1 and the other electrodes.

(Unless otherwise specified, voltage values are positive with respect to Grid No. 1)

MAXIMUM RATINGS, Design-Centre Values:

ULTOR TO GRID No. 1 VOLTAGE	20,000 volts
GRID No. 4 TO GRID No. 1 VOLTAGE:	
Positive value	1,000 volts
Negative value	500 volts
GRID No. 2 TO GRID No. 1 VOLTAGE	640 volts
GRID No. 2 TO CATHODE VOLTAGE	500 volts
CATHODE TO GRID No. 1 VOLTAGE:	
Positive peak value	200 volts
Positive bias value	140 volts
Negative bias value	0 volts
Negative peak value	2 volts
PEAK HEATER-CATHODE VOLTAGE:	
Heater negative with respect to cathode:	
During equipment warm-up period not exceeding 15 seconds	410 volts
After equipment warm-up period	180 volts
Heater positive with respect to cathode	180 volts

EQUIPMENT DESIGN RANGES:

(With any Ultor to Grid No. 1 Voltage (E_{c5g1}) between 12,000‡ and 20,000 volts and Grid No. 2 to Grid No. 1 Voltage (E_{c2g1}) between 220 and 640 volts)

Grid No. 4 to Grid No. 1 Voltage for Focus*	0 to 450	volts
Cathode to Grid No. 1 Voltage for Visual Extinction of Focused Raster	8.5% to 19.4% of E_{c2g1}	volts
Cathode to Grid No. 1 Video Drive from Raster Cut-off (Black Level): White-Level Value (Peak Negative):	— 8.5% to — 19.4% of E_{c2g1}	volts
Gride No. 4 Current	— 25 to + 25	μamp
Grid No. 2 Current	— 15 to + 15	μamp
Field Strength of Adjustable Centring Magnet	0 to 8	oersteds

EXAMPLES OF USE OF DESIGN RANGES:

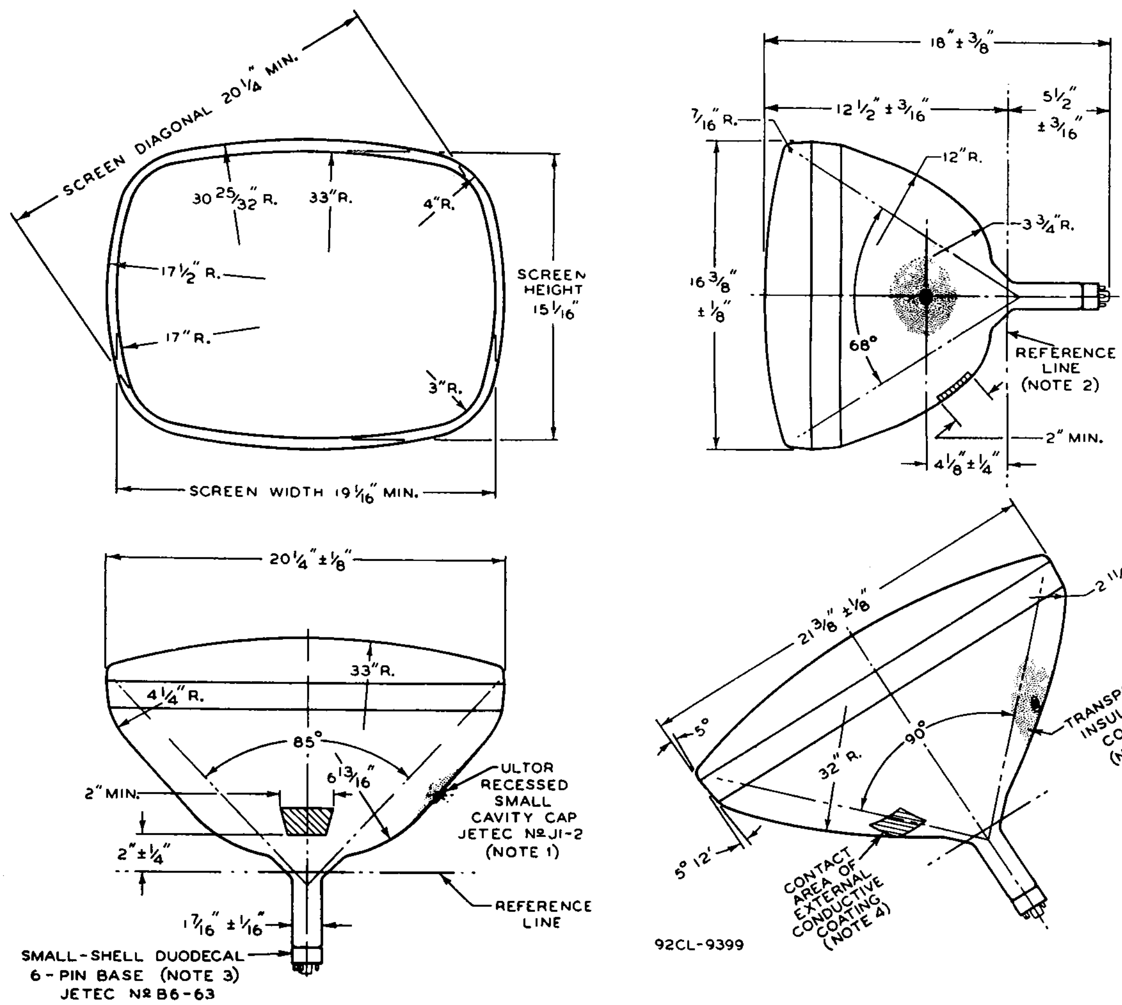
With Ultor to Grid No. 1 Voltage of	16000	18000	volts
And Grid No. 2 to Grid No. 1 Voltage of	300	400	volts
Grid No. 4 to Grid No. 1 Voltage for Focus	0 to 450	0 to 450	volts
Cathode to Grid No. 1 Voltage for Visual Extinction of Focused Raster	28 to 60	36 to 78	volts
Cathode to Grid No. 1 Video Drive from Raster Cut-off (Black Level): White-Level Value (Peak Negative)	— 28 to — 60	— 36 to — 78	volts

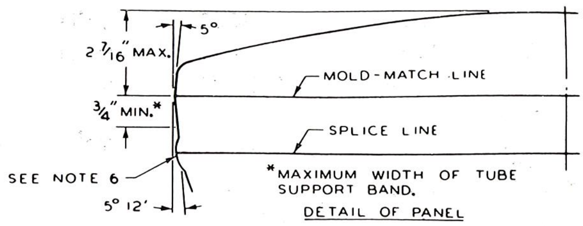
MAXIMUM CIRCUIT VALUE:

Grid No. 1 Circuit Resistance	1.5	megohms

‡ Brilliance and definition decrease with decreasing ultor voltage or ultor-to-grid-No. 1 voltage. In general, the ultor voltage or the ultor-to-grid-No. 1 voltage should not be less than 14,000 volts.

* The Grid No. 4 Voltage or Grid No. 4 to Grid No. 1 Voltage required for focus of any individual tube is independent of Ultor current and will remain essentially constant for values of Ultor Voltage (or Ultor to Grid No. 1 Voltage) or Grid No. 2 Voltage (or Grid No. 2 to Grid No. 1 Voltage) within design ranges shown for these items.





Note 1

The plane through the tube axis and pin No. 6 may vary from the plane through the tube axis and bulb terminal by angular tolerance (measured about the tube axis) of $\pm$ 30°. Ultor terminal is on the same side as Pin No. 6.

Note 2

With tube neck inserted through flared end of reference-line gauge (JETEC No. 116) and with tube seated in gauge, the reference line is determined by the intersection of the plane CC′ of the gauge with the glass funnel.

Note 3

Socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. Bottom circumference of base shell will fall within a circle concentric with bulb axis and having a diameter of $2\frac{3}{4}$".

Note 4

The drawing shows minimum size and location of the contact area of the external conductive coating. The actual area of this coating will be greater than the contact area so as to provide the required capacitance. External conductive coating must be grounded.

Note 5

To clean this area, wipe only with soft dry lintless cloth.

Note 6

Seal bulge may protrude not more than $\frac{1}{8}$" beyond maximum indicated value for envelope width, diagonal or height.

THE RADIAL BEAM DUO-SPEAKER (continued)

case of a rectangular-section enclosure. The disturbance to reproduction by one, not to say three ringing tones is ruinous to good reproduction. In the corner version of the enclosure, only the top and bottom surfaces can be parallel, and even this can be corrected by slanting the lower surface at about 15° to the horizontal, so that no two are parallel. If this procedure is followed, no sound-absorbing material need be used as a lining to the enclosure.

Where a lining material is required, it must be remembered that hair felts have almost no significance at the frequencies at which standing waves occur in a practical enclosure. It is better practice to use a shelf of rockwool or slagwool, about two inches in thickness, and located between the speaker and the vent. This material has insufficient strength to support itself, and the necessary support may be provided by a shelf of chicken wire. The rockwool must extend over the entire internal horizontal area of the cabinet.

There is, of course, no reason why vented enclosures should not be attractive in appearance, and the sketches provided in the heading of this article illustrate two decorative possibilities. The outline drawings provide the necessary constructional details for the two types of enclosure discussed, the standard or "rectangular" type and the corner type. It will be seen that the "rectangular" type of enclosure is constructed with the two side walls at an angle of 5° to the vertical; this not only removes the parallelism between them, but enhances the appearance of the enclosure by taking away the "boxy" look