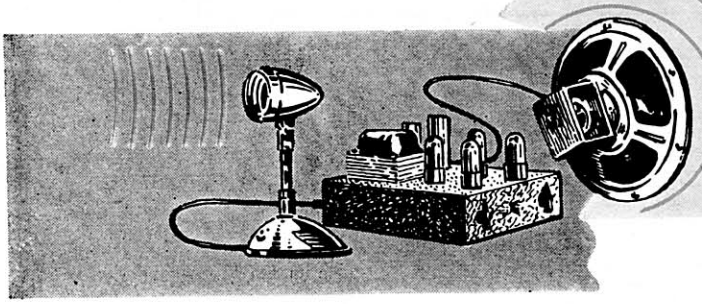
The RECORDING and REPRODUCTION of SOUND



By OLIVER READ
Editor, RADIO NEWS

Part 1. The behavior of sound waves — introduction to a new series of articles covering the history, development, and applications of all currently known methods employed for the recording and reproduction of sound. Mechanical, electrical, and electronic methods will be covered, including sound on wire, disc, tape, film, etc.

TO FULLY understand the many problems which enter into the recording and reproduction of sound, we must first take into consideration the basic concept of sound. We must understand and fully appreciate the characteristics of sound or we cannot apply satisfactory techniques to obtain a true facsimile of the original sounds we expect to reproduce.

Webster defines *sound* as follows: "Sensation due to stimulation of the auditory nerves and auditory centers of the brain, usually by vibrations transmitted in a material medium (commonly air) affecting the organ of hearing—vibration energy which occasions such a sensation. Sound is propagated by progressive longitudinal vibratory disturbances (sound waves)." Thus, it becomes apparent that the source of sound lies in the realm of physics, while the effect of sound is a physiological consideration. The engineering of sound consists of controlling the cause so as to produce the desired effect.

The theory of *sound waves* may be explained in simplified form thusly: If a small stone is dropped into a pool of still water, waves will be set up which will travel in all directions away from the point of impact. If our original stone were small in physical size, only waves small in height would result. However, if a large stone were dropped into the still water, we would discover that we have generated waves having a greater height. The up and down movement of the waves represents the *amplitude* or the intensity of the waves.

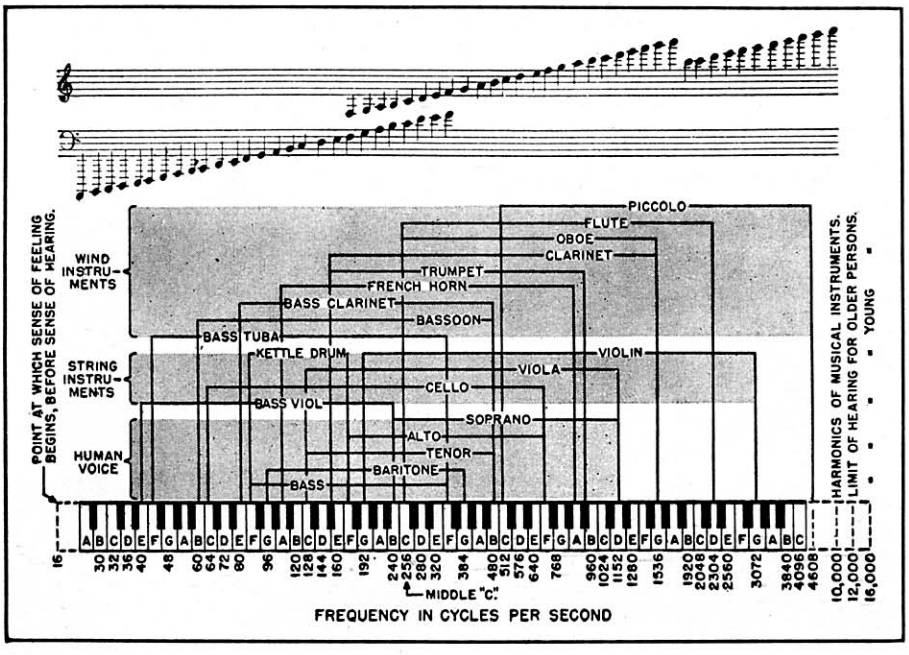
Differing from the behavior of water waves, sound particles of air do not move up and down and across in the pattern in which waves move but all move in the same direction. These particles of disturbed air literally bump one another as they travel through space. The air, therefore, is alternately compressed and rarefied.

The number of waves passing any fixed point per second represents the *frequency* or number of waves per second. Therefore, the *frequency* depends upon the number of waves traveling past one spot during an interval of one second. If we tie a string to a stone which is immersed in still water and move it up and down at the rate of 100 times per second, we will send out waves from the point of impact at the rate of 100 per second. In the study of acoustics we refer to *frequency* in terms of cycles per second, abbreviated c.p.s.

Now suppose we took a large stone and moved it up and down very slowly in and out of the water, we would then set up waves at a lower frequency but, due to the greater displacement of the water by the object, we would create waves of greater amplitude.

The top of the wave is referred to as the *crest,* while the bottom is known as the *trough.* One *cycle,* as far as one wave is concerned, would be one complete wave beginning from its normal still point, building up to a crest, passing again through its still point,

Fig. 1. Frequency range of musical instruments and those covering the human voice.



down to the lowest point, the trough, and its return to its normal position. See Fig. 4D.

Sound waves are not limited to but one frequency. In fact the speaking voice is made up of a variety of *complex waves.* These are continually varying in both frequency and amplitude. In other words, if we raise our voices in *pitch,* we are actually increasing the *frequency* and the *louder* we talk, the greater will be the *amplitude* of the sound waves sent out by our speaking mechanism.

All sound waves are composed of frequency, intensity, periodicity, and waveform.

1. *Frequency* is the speed of vibration or number of complete cycles per second. Frequency also determines pitch. If we double the speed of vibration, we raise the pitch one octave. For example, a note having 1000 vibrations or cycles per second would be raised by one octave if the frequency were doubled to 2000 c.p.s.

2. *Intensity* is the amplitude or power of vibration. Intensity therefore determines the loudness of a sound. If the pressure of a sound wave is doubled in intensity, we increase the power by about 3 decibels. The *decibel* is a ratio of power and not a quantity.

In the behavior of sound waves various ranges of intensities and pressures are so great that it is necessary to have some means which will conveniently measure volume or amplitude. The *decibel* is a unit used for expressing the magnitude of a change in either a sound level or a signal level. One decibel is the amount that the pressure of a pure sine wave tone must be changed in order for the change to be just barely detectable by the average human ear. The amount of change in power level expressed in decibels is equal to ten times the common logarithm of the ratio of the two powers. db. $= 100 \log_{10} P_1/P_2$.

3. *Periodicity* is the lack of, or the existence of, rhythm in sound. Therefore, musical sounds are *periodic,* while street noises, the jingle of keys on a chain, etc. are *non-periodic.*

4. *Waveform* is a direct pattern of vibration. Most fundamental sound waves are modified by secondary vibrations. The *timbre* of sound is determined by the waveform. Thus it is possible to distinguish particular notes played on various musical instruments such as the violin and the flute.

Distortion

If a microphone, radio tuner, pickup, amplifier or speaker is incapable of reproducing a true picture of the original sound waves, *distortion* will occur. This distortion may come from either mechanical or electrical defects in the system. *Mechanical distortion* may be caused from such conditions as having a needle in a phonograph pickup move because it has not been tightened thoroughly by means of the needle set screw. In other words, vibrations set up within the pickup could not transmit or move the needle in perfect cadence with the original electrical vibrations. The needle would be permitted to move freely and to follow vibrations of its own choice instead of moving in perfect unison with the armature in the pickup.

Many reproducer (loudspeaker) cones vibrate at some particular frequency not found in the music that is fed to the speaker for reproduction. The resulting buzzing effect would be a form of *mechanical distortion.* The above illustrations are typical but many others may be encountered throughout the equipment if care is not exercised to adjust each and every part which might cause mechanical distortion.

Generally speaking, a sound is said to be distorted when the waveform is altered in transmission or when the intensity of any frequency is suppressed or exaggerated out of its natural proportions.

Electrical distortion is caused by the inability of the microphone, amplifier or speaker to give a true reproduction (facsimile) of frequency. For example; the delicate diaphragm on a microphone may become warped from excessive heat, etc. As pressure from the sound waves strikes this distorted diaphragm, the resulting currents

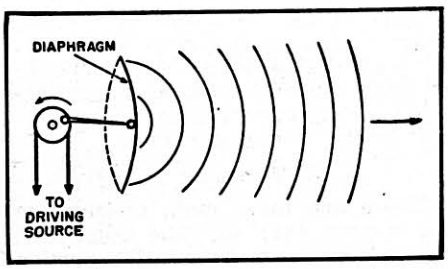


Fig. 2. Sound waves created by the movement of a mechanically-driven diaphragm.

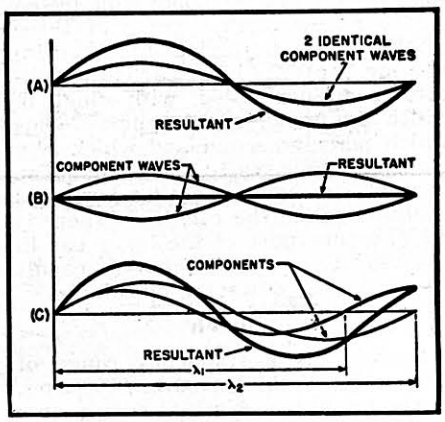
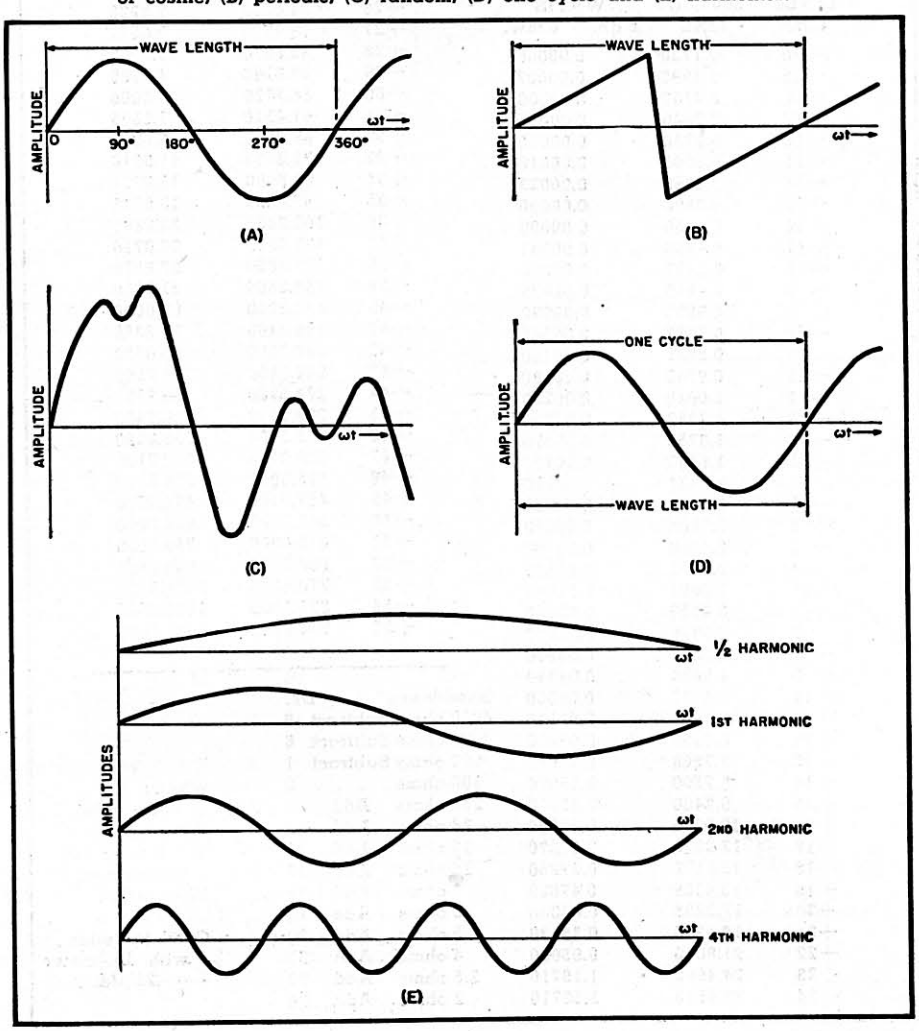


Fig. 3. The combination of two harmonic waves vibrating at the same frequency.

Fig. 4. Illustrating the characteristic behavior of wave motion: (A) sine or cosine, (B) periodic, (C) random, (D) one cycle and (E) harmonics.



would become distorted. There are many forms of electrical distortion. A poorly designed amplifier, overloaded audio stages, impedance mismatching and improper biasing will all result in electrical distortion.

The Ear

There are three main divisions to the human ear: (a) The outer ear, which is made up of the visible portion of the ear and the canal which is not visible. (b) The middle ear, which is the receiver for sound approaching the eardrum and the conducting media for sounds through a chain of three small bones (the ossicles), to the inner ear. (c) The inner ear is the delicate container filled with fluid in which is immersed the nerve ends which perceive sound and which also transmit messages to the brain. The part of the inner ear that perceives sound is called the cochlea. There is still another part of the inner ear in the form of semi-circular canals which give us our sense of balance.

Speech

Speech has a frequency range of from approximately 100 to 8000 c.p.s. There are three principal components to speech. They are listed as follows:

1. The *fundamental* range (or voice). 100 to 400 c.p.s.
2. The *vowel* range. 300 to 2500 c.p.s.
3. The *consonant* range. 2000 to 8000 c.p.s.

The above are approximate ranges and do not necessarily indicate the proportion of sounds that occur in each division. Sounds having very low frequencies possess the most power and result in naturalness and apparent loudness. High frequency sounds provide intelligibility. If we eliminate all sounds below 1000 c.p.s., we take but little from the clarity of the sound, but we do notice that the sound appears to be unnatural. However, if we eliminate sounds above 1000 cycles, we find that the speech is unintelligible but, as far as volume is concerned, there is little, if any, apparent change.

Speech may be considered as a series of *periodic* sound waves, emitted in a certain sequence. Association of particular sound sequences with particular ideas is the distinguishing feature between speech and noise. The so-called "scrambled" speech systems serve as an excellent illustration of this point. In such a system, spoken sounds are distorted by specially designed circuits and then transmitted in the distorted form. The receiver must have a rectifying circuit to convert the wave impulses back to their original undistorted form rendering it intelligible to the human ear.

Music

That sound we choose to call music consists of a sequence of single tones or a sequence of several tones played in unison. Pure single tones are harmonic in waveform and the key or pitch is determined by the frequency (with certain modification to be discussed later). The scale is an ascending series of tones with definite frequency intervals. Fig. 6 shows a portion of a standard piano keyboard for one octave on each side of middle C. The frequencies noted represent a so-called tempered scale which divides an octave into twelve equal intervals. The relative frequencies of the tempered scale (omitting sharps and flats) are shown below for one octave:

Key	Relative Frequency
C	1.000
D	1.122
E	1.260
F	1.325
G	1.498
A	1.682
B	1.887
C	2.000

The combinations of two or more tones make up a periodic composite sound. Here again the psychological phase of music shows up, for if the new sound is pleasing to the ear, it is called harmonious. If, on the other hand, the sound is irritating, the combination of tones is said to be in discord.

Frequency Range

If a tone is maintained at a constant intensity but its frequency is raised and lowered, high and low frequency points will be reached beyond which there will be no sensory perception by the ear. Generally this *frequency range* extends from 30 to 16,000 c.p.s. The frequency range for conversational speech is from about 100 to 8000 c.p.s., as mentioned previously. In terms of power, conversational speech will vary over about 40 db. and the intensity of the loudest sound will be about 10,000 times that of the weakest.

A large symphony orchestra, with instruments producing an abundance of bass notes and overtones extends over practically the entire frequency range of the ear—30 to 16,000 c.p.s. The over-all volume range of a symphony orchestra from the softest passages through the loudest passages and peaks runs about 70 db. or an intensity range of 10,000,000 times.

Reproducing systems for highest fidelity should have a frequency range that is uniform from about 30 to 16,000 c.p.s. and a volume range of 70 db.

Of equal importance, the original sounds must be reproduced at the same power levels as were present in

(*Continued on page* 88)

Fig. 5. Conversion chart for standard 500 ohm db. meter across impedances from 2-4000 ohms.

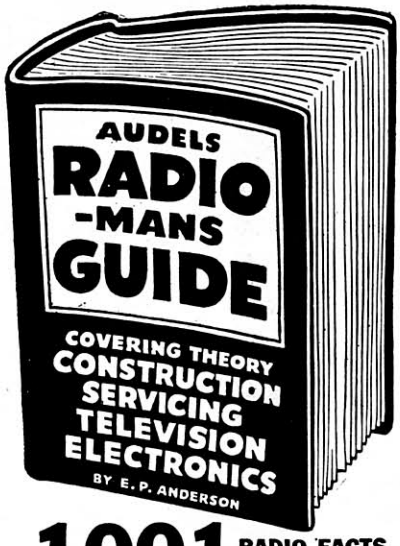
POWER LEVEL (db.)	VOLTS 500 OHM LINE	POWER WATTS 0 db. = 6 mw.
−20	0.1730	0.00006
−19	0.1990	0.00007
−18	0.2180	0.00009
−17	0.2340	0.00011
−16	0.2730	0.00015
−15	0.3000	0.00018
−14	0.3390	0.00023
−13	0.3890	0.00030
−12	0.4450	0.00039
−11	0.4860	0.00047
−10	0.5477	0.00060
− 9	0.6145	0.00070
− 8	0.6895	0.00090
− 7	0.7737	0.00110
− 6	0.8681	0.00150
− 5	0.9740	0.00180
− 4	1.0928	0.00230
− 3	1.2262	0.00300
− 2	1.3758	0.00370
− 1	1.5437	0.00470
0	1.7321	0.00600
+ 1	1.9434	0.00750
+ 2	2.1805	0.00950
+ 3	2.4466	0.01190
+ 4	2.7451	0.01500
+ 5	3.0801	0.01890
+ 6	3.4559	0.02380
+ 7	3.8776	0.03000
+ 8	4.3507	0.03800
+ 9	4.8680	0.04740
+10	5.4772	0.06000
+11	6.1600	0.07590
+12	6.8100	0.09480
+13	7.7368	0.11970
+14	8.7100	0.15070
+15	9.7400	0.18970
+16	10.9285	0.23880
+17	12.2620	0.30070
+18	13.7578	0.37850
+19	15.4369	0.47660
+20	17.3205	0.60000
+21	19.4340	0.75530
+22	21.8050	0.95090
+23	24.4660	1.19710
+24	27.4510	1.50710
+25	30.8010	1.89740
+26	34.5590	2.3886
+27	38.7760	3.0071
+28	43.5070	3.7857
+29	48.8160	4.7660
+30	54.7720	6.0000
+31	61.4550	7.5535
+32	68.9540	9.5093
+33	77.3680	11.9716
+34	86.8080	15.0713
+35	97.4000	18.9747
+36	109.2850	23.8865
+37	122.6200	30.0710
+38	137.5820	37.8570
+39	154.3690	47.6600
+40	173.2050	60.0000
+41	194.3400	75.5350
+42	218.0500	95.0930
+43	244.6600	119.7160
+44	274.5100	150.7130
+45	308.0100	189.7470
+46	345.5900	238.8650
+47	389.0700	300.7100
+48	435.6000	379.5000
+49	487.0100	474.3700
+50	547.7200	600.0000
+51	616.0300	759.0000
+52	688.7400	948.7500
+53	770.4000	1185.9400
+54	871.2000	1518.0000
+55	974.0300	1897.5000

Impedance		DB.
4000 ohms	Subtract	9
2000 ohms	Subtract	6
600 ohms	Subtract	1
500 ohms	.....	0
250 ohms	Add	3
24 ohms	Add	13
15 ohms	Add	15
10 ohms	Add	17
8 ohms	Add	18
6 ohms	Add	19
5 ohms	Add	20
4 ohms	Add	21
2.5 ohms	Add	23
2 ohms	Add	24

$E = \sqrt{WZ}$
where:
E = a.c. volts across load
Z = loaded line impedance.
W = watts.

Cond. in Series with db. meter = .25 μfd.

7 Days
Free Examination



1001 RADIO FACTS AND FIGURES

AUDELS RADIOMANS GUIDE—914 Pages, 633 Illustrations, Photos, Wiring Diagrams, 38 Big Chapters, covering Radio Theory, Construction, Servicing, including Important Data on Developments in Television, Electronics and Frequency Modulation, Review. Questions and Answers, Calculations & Testing. Highly Endorsed—Indispensable for Ready Reference and Home Study.

$4 COMPLETE • PAY ONLY $1 A MONTH

Step up your own skill with the facts and figures of your trade. Audels Mechanics Guides contain Practical Inside Trade Information in a handy form. Fully illustrated and Easy to Understand. Highly Endorsed. Check the book you want for 7 days' Free Examination.

Send No Money. Nothing to pay postman.

CUT HERE

MAIL ORDER

AUDEL, Publishers, 49 W. 23 St., NEW YORK 10, N. Y.

Please send me postpaid for FREE EXAMINATION books marked (x) below. If I decide to keep them I agree to mail $1 in 7 Days on each book ordered and further mail $1 monthly on each book until I have paid price. Otherwise, I will return them.

- ☐ RADIOMANS GUIDE, 914 Pages . . . . . $4.
- ☐ ELECTRICIANS EXAMINATIONS, 250 Pages . 1.
- ☐ WIRING DIAGRAMS, 210 Pages . . . . . 1.
- ☐ ELECTRICAL DICTIONARY, 9000 Terms . . 2.
- ☐ ELECTRICAL POWER CALCULATIONS, 425 Pgs. 2.
- ☐ HANDY BOOK OF ELECTRICITY, 1340 Pages 4.
- ☐ ELECTRONIC DEVICES, 216 Pages . . . . . 2.
- ☐ ELECTRIC LIBRARY, 12 vol., 7000 Pgs., $1.50 vol.
- ☐ OIL BURNER GUIDE, 384 Pages . . . . . 1.
- ☐ REFRIGERATION & Air Conditioning, 1280 Pgs. 4.
- ☐ POWER PLANT ENGINEERS Guide, 1500 Pages. 4.
- ☐ PUMPS, Hydraulics & Air Compressors, 1658 Pgs. 4.
- ☐ WELDERS GUIDE, 400 Pages . . . . . 1.
- ☐ BLUE PRINT READING, 416 Pages . . . . . 2.
- ☐ SHEET METAL WORKERS Handy Book, 388 Pgs. 1.
- ☐ SHEET METAL PATTERN LAYOUTS, 1100 Pgs. 4.
- ☐ AIRCRAFT WORKER, 240 Pages . . . . . 1.
- ☐ MATHEMATICS & CALCULATIONS, 700 Pgs. . 2.
- ☐ MACHINISTS Handy Book, 1600 Pages . . . 4.
- ☐ MECHANICAL Dictionary, 968 Pages . . . . . 4.
- ☐ AUTOMOBILE GUIDE, 1540 Pages . . . . . 4.
- ☐ DIESEL ENGINE MANUAL, 400 Pages . . . 2.
- ☐ MARINE ENGINEERS Handy Book, 1280 Pages 4.
- ☐ SHIPFITTERS Handy Book, 272 Pages . . . 1.
- ☐ MECHANICAL DRAWING COURSE, 160 Pages 1.
- ☐ MECHANICAL DRAWING & DESIGN, 480 Pgs. 2.
- ☐ MILLWRIGHTS & Mechanics Guide, 1200 Pgs. 4.
- ☐ CARPENTERS & Builders Guides (4 vols.). . 6.
- ☐ PLUMBERS & Steamfitters Guides (4 vols.) . 6.
- ☐ MASONS & Builders Guides (4 vols.) . . . . 6.
- ☐ MASTER PAINTER & DECORATOR, 320 Pgs. 2.
- ☐ GARDENERS & GROWERS GUIDES (4 vols.) 6.
- ☐ ENGINEERS and Mechanics Guides Nos. 1, 2, 3, 4, 5, 6, 7 and 8 complete . . . 12.
- ☐ Answers on Practical ENGINEERING . . . . 1.
- ☐ ENGINEERS & FIREMANS EXAMINATIONS . 1.

Name_____

Address_____

Occupation_____

Employed by_____ RN

Sound Recording

(*Continued from page 54*)

the studio. This is important if proper *balance* between the lower and higher frequencies is to be maintained.

When a sound is reproduced at a higher level than that of the original, the low bass frequencies will appear to be *accentuated*. If the sound is reproduced at a lower level than the original, bass frequencies will appear to be *attenuated* (suppressed) with respect to other portions of the frequency spectrum.

Noise

Noise is usually considered to be *random* sound waves with little or no periodicity. That does not completely define noise for certain "noises" are associated with certain commonplace events; for instance, the creaking of doors or gates, the clicking sound made by walking on a hard surface with leather heels, etc. The hum of an electric motor is considered noise, yet an analysis of the sound by means of an oscillogram would indicate a definite periodicity. Again it seems that the distinction between the classification of sounds is psychological in origin and relative to the observer.

The Technical Aspects of Sound

Sound is usually characterized as wave motion of which there may be three forms, namely, harmonic, periodic, and random.

Waves are propagated disturbances and may be *transverse* or *longitudinal*, depending upon the direction of the disturbance.

In a *transverse* wave, the particles of the medium vibrate in a direction perpendicular to the direction of propagation. For example, in a water wave, the individual particles of water move up and down, while the direction of wave motion is along the surface, or perpendicular to the particle motion. Thus, a water wave is a transverse wave.

A *longitudinal* wave is so named because the particles of the medium vibrate in a direction parallel to the direction of propagation. In a sound wave, for example, the individual particles of air move back and forth in the same direction that the wave is traveling. Thus, a sound wave is a longitudinal wave.

A *wavefront* may be classified as *plane* or *spherical*. Since a wave in general spreads out uniformly in all directions from its source or origin, the wavefront will be spherical close to the source. However, at some distance from the source the curvature is practically zero, and the wave is considered to be a plane wave. If a pebble is dropped in a still pond, circular waves will spread out in all directions, but by the time they have traveled a considerable distance, the waves will be essentially straight. Thus, a wave which starts out spherical (or circular in two dimensions) eventually becomes essentially a plane wave.

Harmonic Motion is a wave pattern of the sine or cosine curve type as in Fig. 4A. All harmonic motion can be described by an equation of the form: $y = A \sin \omega t$

where: y = displacement of the disturbance, A = maximum displacement (which occurs at 90° and 270°), ω = circular frequency (to be defined in detail) in degrees per second, t = time after disturbance is initiated.

Periodic Motion is a wave pattern compounded from two or more harmonic motions of different frequencies as in Fig. 4B. Periodic motions are analyzed by determining the various harmonic components. The character of any periodic motion is controlled by the number and magnitude of its various harmonic components.

Random Motion is a conglomeration of harmonic motions exhibiting little or no periodicity. Speech, squeaks, scraping, etc., all produce random motion unless they are sustained for long periods. The number of harmonic components is so great and their duration is so irregular as to make the harmonic analysis of random motion a practical impossibility. A typical wave pattern of random motion is shown in Fig. 4C.

Harmonic and periodic motions have certain defining characteristics which must be considered. These are:

Cycle, which is a sequence of events or motions that recur in exactly the same order in certain time intervals. For example, the motion of a pendulum started from one side, allowed to swing to the opposite and back to the starting side, comprises one complete cycle. This is illustrated in Fig. 4D.

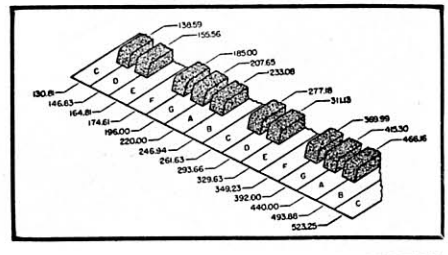
Period is the time required for the motion to complete one set of recurring values, or one cycle. It is usually defined by the symbol T.

Frequency is the rate at which the cycles recur and is usually presented in one of two ways. If the frequency is given as ω, it is known as the circular frequency and has the dimensions, radians per second. The frequency may also be given as cycles per second or the symbol f in which case it is connected to the circular frequency by the relation: $f = \omega/2\pi$

Wavelength is the distance between two corresponding points on harmonic or periodic waves (Fig. 4A) and is denoted by the symbol λ.

Fundamental Frequency is the low-

Fig. 6. Diagram illustrates section of a piano keyboard and shows tempered scale for one octave on each side of middle C.



LEOTONE MONTHLY SPECIALS

SERVICEMEN'S KITS

1—R.F., Antenna & Osc. coils; 10 asstd. $0.98
2—Speaker Cones; 12 asstd. 4" to 12" moulded & free-edge (magnetic incl.). Less voice coil 2.00
3—BAKELITE MICA CONDENSERS; 50 asstd. .00001 to .2mfd, 200-600WV Clearly marked 2.95
4—Tubular By-Pass Condensers; 50 asstd. .001 to 25mfd 200-600 Standard brands 2.49
6—Dial Scales; 25 asstd. airplane & slide-rule (acetate & glass included). 2.98
7—Escutcheon Plates; 25 asstd. airplane slide-rule & full vision type 2.95
8—Knob; 25 asstd. wood & bakelite, including setscrew & push-on types. . . 1.00
9—Wafer Sockets; 12 asstd. 4 to 7 prong .25, 50 for 1.00
#10—Voltage Dividers, 10 asstd. standard multi-tapped High Wattage included. 1.98
#11—Shield Cans; 15 asstd. for tube, coils, transformers, etc. 1.00
#12—Mica Padders & Trimmers; 15 asstd. incl. multiple & ceramic base types. .69
#14—Volume & Tone Controls; 10 asstd. wire-wound & carbon. Less switches 1.49
#15—Wire-Wound Resistors; 15 asstd. ohmages 5 to 20 watts 98
#16—I F Coils; 6 asstd. including shielded & slug tuned Peaks unmarked 1.95
#17—Dial Windows; 12 asstd. sizes incl. flat & moulded acetate and convex glass 1.29
#18—Bakelite Coil Forms; 18 asstd. Popular sizes up to 3" Diameter 98
#19—High Resistance Units; 25 asstd. carbon, ferrule-ended. 50,000 to 5 megohms 49

RADIO HARDWARE TREASURE. Over 1000 screws, nuts, washers, etc., PLUS handy 36 compartment cardboard kit box $0.59

TUBES: Perfect condition, but NOT in sealed cartons. Guaranteed for 90 days. #26, 27, or 56—29c; #24, 42, 75, 77, 78, 89, 6D6, 6H6, or 6K7—39c; #50, 6A3, 6A8, or 6F5 . . . . . 59c

Brand New R.C.A. UX-200 tubes in sealed cartons (triode detector), 8 for $1.00
Phono Scratch Filter Transformer 1⅞"x1¼" sq.) with hum adjustment, allowing alternate use in UHF Quench Osc. circuit 39
EXPERIMENTAL TUBES. 20 asstd. sizes & base types for testing, research, etc. Fil. tested 1.00
Victor Power Transformers for models R-32, 45, 52, or 75 Unshielded 5.95

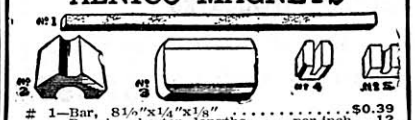
!!! Surplus Specials !!!

DYNAMOTORS (Navy DY-9/ARC-1) DC input: 26V DC output: 300V, @ 355ma. Black crackle finish, mtg. base. 6½x3½ $3.95
DPDT TOGGLE SWITCHES (H&H), external lugs. 6A/125V. Bakelite case, split ball 39
2 conductor transmission cable. Flexible twisted, stranded, tinned rubber covered. Ideal for communication, P. A. or light electrical work. 3c ft.; 250 ft. 5.00

16" N.B.C. RECORDINGS; for home, P.A. systems, demonstration, etc. Each contains 2 complete different 15 min. "Voice of the Army" dramatic programs with music. Over 60 different titles, such as: Wings of Paradise, V-E Day, Combat Dog, etc. 33⅓ RPM. 5 asstd. records $1.49

Weston #301, 0-50 Voltmeter (modulation) A.C. rectifier, 1000 ohms per volt. 3" bakelite . . . . . $ 3.95
SELSYN 5G SYNCHRO-TRANSMITTERS, 115V, 60 cycle. Brand new. Operate in pairs as trans. & follower. 3½"x5". Per pair (shpg. wt. 12 lbs.) 10.49
4 TUBE AMPLIFIER (2-7C5, 7F7, 7Y4). Used as electronic supercharger control 110V, 400 cycle. Contains: power trans., 7 condensers (mica & oil), 7 resistors, 4 loctal sockets plus other components worth several times the price. Black crackle finish can; slide-in chassis. 8¾"x4½"x3¾". Less tubes 1.49
EARPHONE HEADBANDS (HS-33). Leather covered; adj. frame & forks. With PL-54 & double phone cord 39
PL-54 plug & 13" tinned dble. phone cord 19

ALNICO MAGNETS



1—Bar, 8⅛"x1¼"x⅛" $0.39
Bar in shorter lengths . . . . per inch .12
2—Face 1¼"x1¾"x⅞" high 98
3—Heavy duty bar, 2½"x1⅜"x5/16" . . .98
4—Face ¾"x⅝"x⅝" high 39
5—Polished, face ⅞"x9/16"x¾" high . .35
6—Polished bar, 9/16"x¼"x⅛" . . 20 for 1.00
7—Face ½"x½"x⅜" high 10
8—ALNICO V, h'shoe, poles ⅜" sq.; 1¼" high 75
9—ALNICO V, h'shoe, poles 9/16" sq.; 1½" high 98
#10—ALNICO V, h'shoe, poles 1"x1½"; 2¾" high 5.95
#11—Horseshoe, cn. pole 11/16" O.D., 2¼" high 1.29
#12—(Similar to #5) ¾"x⅜"x7/16" 35
#14—Polished hvy. duty bar; 3"x1¼"x ⅞" Magnetized lengthwise, wide or narrow sides 1.29

PROMPT SERVICE ON ALL SPEAKERS & PHONO PICKUP REPAIRS. Minimum Order $2.00—20% Deposit Required on All Orders. Please Add Sufficient Postage. WRITE DEPT. RN-3.

LEOTONE RADIO CO.

MAKERS OF CONES AND FIELD COILS
65-67 DEY STREET. NEW YORK 7, N.Y.
WORTH 2-0284-5
12,000 SQ FT OF RADIO PARTS

est component frequency of a periodic wave motion.

Harmonic Frequency or overtone, when applied to music, is that component of a periodic wave motion whose frequency is an integral multiple of the fundamental frequency.

Sub-Harmonic Frequency is that component of a periodic wave whose frequency is an integral submultiple of the fundamental frequency.

An *Octave* is the interval between two waves whose frequencies are in the ratio of 1:2.

Each of these above four terms is illustrated in Fig. 4E.

Behavior of Sound Waves

From a purely physical concept, sound can be considered as an alteration in pressure, displacement of particles, or the velocity of particles in elastic media. These pressure or velocity changes are produced by a *transducer,* which is an electro-mechanical or electro-acoustic system for converting electrical vibrations into mechanical or acoustical vibrations respectively. Microphones and loudspeakers are typical transducers as is the sounding diaphragm of Fig. 2. The motivating source for the diaphragm can be mechanical (as shown) or electrical as in the case of a loudspeaker. Since sound is a particular type of wave motion, it becomes desirable to consider particular behavior of waves.

1. If two harmonic waves pass through the same point while vibrating at the same frequency, the resultant wave formed by adding the displacements will also be a harmonic wave.

2. Conversely, any harmonic wave can be resolved into a number of component harmonic waves. This principle is covered by *Fourier's Theorem.*

3. If two harmonic waves start at the same point and experience similar displacements at the same time, they are said to be *in phase* with each other. However, if one wave lags or leads the other, then they are said to be *out of phase* (Fig. 3B). It is customary to denote phase difference in angular units as that part of 360 degrees or 2 π radian.

Almost everyone has witnessed some example of wave interference. For instance, in Fig. 3A, the component waves (both are identical and appear as one) form a harmonic wave at twice the original amplitude. This is said to be *constructive interference.* In Fig. 3B the component waves are of the same frequency and amplitude but 180 degrees out of phase, and therefore, cancel each other in what is called *destructive interference.* The resulting wave caused by the superposition of two waves of almost, but not quite the same frequency as in Fig. 3C has the characteristic of *beats,* i.e. alternate periods of constructive and destructive interference. Beat phenomena are particularly important in their application to superheterodyne reception.

When two identical waves travel with the same speed but in opposite directions, the resulting wave is known as a stationary or *standing wave.* While there is no translational motion, the vibratory displacements persist. The displacements are of equal magnitudes for distances one-half wavelength apart and the wave takes the form shown in Fig. 7A at some particular time and then reverses as shown in Fig. 7B. As can be seen from the figure, certain portions of the wave experience little or no displacement. The points of maximum displacement are called *anti-nodal points* or *loops* and the points of zero displacement are called *nodal points.* Standing waves are of great importance in the theory of antenna design.

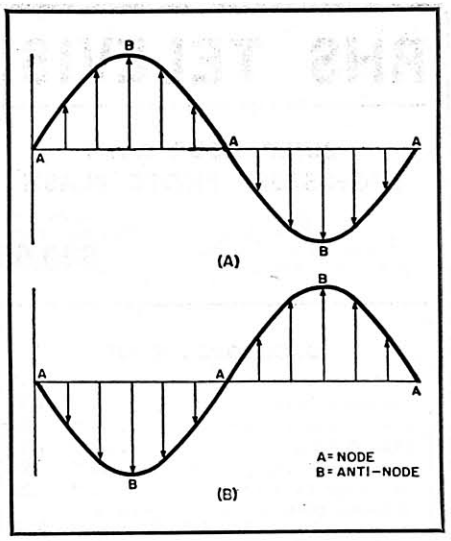


Fig. 7. Illustrates displacement of waves.

The Speed of Sound

The speed of sound in any medium is a function of the density and elastic qualities of the medium.

The variation of the speed of sound with temperature is expressed by the formula:

$$v_t = v_o \sqrt{1 + \frac{1}{273}\, t}$$

where:

v_t = velocity at temperature t
v_o = standard velocity at 0° C
t = temperature in degrees C

The speed of sound in air at one atmosphere pressure at 0° C is approximately 1088 ft/sec. while at 100 atmospheres the speed of sound is 1150 ft/sec.

Pitch and Intensity

The pitch of a sound is best characterized by its frequency, except for certain psychological effects. The audible range is known to be between 16 and 20,000 cycles per second, but the average ear does not hear below 30 cycles per second nor above 16,000 cycles. However the pitch, as received by the human ear, is not a direct function of the frequency and varies with the intensity. This effect has been investigated in considerable detail by Fletcher.[1]

[1] Fletcher, H., "Speech and Hearing," D. Van Nostrand, New York, 1929.

While intensity is popularly considered to be synonymous with loudness, a distinct difference exists between the two. The former is a pure physical quantity while the latter is psychological in origin. In a strict physical sense, intensity is defined as the average rate of flow of energy per unit area in a direction normal to the rate of flow. It is expressed by the formula:

$$I = \frac{1}{2}\frac{(p_{max})^2}{\rho_o c}$$

where p_{max} = the maximum pressure developed above the steady pressure for no disturbance, c = wave velocity, ρ_o = medium density, I = intensity in watts/sq. cm.

The equation may also be written in the form:

$$I = \frac{1}{2}\rho_o c\omega^2 d_{max}$$

where d_{max} = maximum displacement and ω = circular frequency = $2\pi f$.

For acoustic measurements, the choice of the equation depends on whether the recording instruments respond to pressure or displacement variations.

Current practice now employs the decibel as a relative measure of intensity. The bel (so named after Alexander Graham Bell) is defined as follows:

$$b = \log_{10}\frac{I_1}{I_2}$$

where I_1 and I_2 are the absolute intensities.

The bel is a large unit, an intensity ratio of 10 to 1 being equivalent to only 1 bel. This would mean dealing with rather small numbers, so it is customary to use the decibel, which is one tenth of a bel. Thus the numbers with which we deal are 10 times as large when speaking of decibels as they are when speaking of bels. To convert to decibels, the value in bels must be multiplied by 10. Thus:

$$\text{db.} = 10\log_{10}\frac{I_1}{I_2}$$

An intensity ratio of 10 to 1 would thus be equivalent to 10 db., and 3 db. would be equivalent to an intensity ratio of 2 to 1.

On the other hand, the loudness of a tone is a function of its frequency and intensity and can be defined as the magnitude or stimulus it creates in the auditory system. This implies a relative measure of loudness and some reference level must be established for comparison. The tone emitted at 1000 cycles at 0 db. is taken as this level and the loudness of any particular tone is determined by adjusting the reference tone until it sounds as loud as the one being tested. The increase in intensity of the reference tone is interpreted in terms of loudness units. Fletcher and Munson have done much work along this line and their results have been published in the *"Journal of the Acoustical Society of America."* Obviously, a certain amount of human error is bound to be injected into such measurements, however, correlation by statistical methods has yielded some very valuable information.

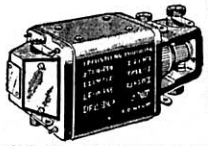
The db. meter used for measuring sound levels has a scale which is usually calibrated from −10 to +6 db. This type of meter is usually calibrated for use across an impedance load of 500 ohms and is actually a voltmeter of the rectifier type. Many systems do not standardize on 500 ohm lines and there are many occasions when it is desirable to use a standard meter across voice coils of speakers, etc. having different impedances.

Fig. 5 shows how such meters may be used across loads of from 2 to 4000 ohms. For example, reference to the table in Fig. 5 will show that if a 500 ohm meter is used across a speaker voice coil of 8 ohms, 18 db. must be added to the meter reading.

Multipliers are needed, as with any other voltmeter, if an additional range over +6 db. is desired. For average meters, the resistance required will be approximately 5000 ohms-per-volt.

In the transmission and reproduction of sound, consideration must be given to the human ear as a transducer (here the sound waves are transformed into a stimulus for the auditory system.) The ear exhibits certain non-linear characteristics which affect the fidelity with which sounds are received. For instance,

(*Continued on page* 157)



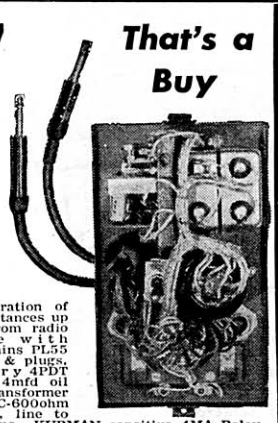
NEW NAVY DYNAMOTORS EICOR DC. GT'D overseas packed. AN insp Hi eff. CONT. duty, input 12V/4A or 24V/2A output 500V/50ma: Input 12V/8A or 24V/4A ouput 275V 110 ma & 12V/3A. Either UNIT $1.95 or both units (2) & filter $3.49. Wgt. 9 lbs., 7¾" L x 2⅞" H x 4¼" W. Adaptable to 6V operation. Alnico Field.

WE BEACHMASTER INPT & PP DRIVER TRANSF 6V6/805's ..... $ 6.95
THERMADOR TRANSF CASED S.C. CONT DUTY, PRI 200 to 440V/50-60cy; SEC 3800VCT/6KV/2.7Amps 45.00
Collins choke 6Hy/1.2Amp/30ohm/12500V wkg.. 16.00
Bendix 1339 Model I Voltage Regulator 115V.. 3.75
Condsr GE Pyranol 15mfd/330VAC/1000WVDC. 2.95
Condsr GE 4 section 28mfd/660VAC/2000WVDC 9.90
Electrolytic CD-20/20mfd-450VDC @ 85. Two for 1.50
Condenser GE Pyranol 1mfd/500WVDC, 8 for.. 1.00
STANCOR 6.4V/12A; 6.4V/10.6A; 5V/3A; 5V3A HV ins. 4.95

Condsr GE Pyr 3mfd/330VAC/1000WVDC, 2 for 2.50
Condsr CD oil 6mfd/1500WVDC, 2 for..... 4.50
Condsr CD oil 2mfd/6000WVDC @ 12.50
Condsr WST Inerteen 2mfd/12500WVDC @ ... 25.00
Condsr WST Inerteen 1mfd/25000WVDC 75.00
Condsr oil CD TLA 2mfd/600WVDC, 2 for.... .79
Condsr AVX #1510 oil 0.5mfd/1500WVDC, 2 for 1.49
Condsr CD 2mfd/5000WVDC @ $7.95; 2 for.... 15.00
Amphenol Octal sockets 78S8TN, 25 for..... 1.50
Condsr mica .01mfd/2500V ($3.40), 2 for..... 1.00
Condsr RF/25mmfd/10000V wkg new, 3 for.... .75

"TAB" New Remote Control Unit RM-53 (RC-261)

That's a Buy



For voice operation of transmitter distances up to ½ mile from radio set. Complete with manual. Contains PL55 & PL68 cords & plugs, jacks Mallory 4PDT switch. Two 4mfd oil condsrs. Transformer multi-tap UTC-600ohm CT line to G, line to 150 or 250ohms. KURMAN sensitive 4MA Relay DP one normally open, other closed. Toggle switch, bushings & waterproof box. **$3.49**
"TAB" SPECIAL $5.25
WITH T17 CARBON MICROPHONE .....

GR VARIAC 200CU/860W/with Dial & K. $14.95
GR VARIAC 200B/170W new S. C. 9.95
SYLVANIA GERMANIUM CRYSTALS 1N34. 1.39
TBY NEW VIBRAPACK & storage battery WILLARD 4V/40AH; output 156V/30ma; 3V 375ma; 1.5v/200ma; 7.5v/20ma.. 9.95
WE DYNAMIC MIKE & 20' CORD..... 9.95
KENYON DYNAMIC MIKE TO G trans..... 1.95
TRANSF L to L/500, 333, 250, 200, 125, 50 ohms ± 1DB..... 1.95
TRANSF CASED PRI 105 to 250V/50-60cy; Sec. 2240VCT 500ma; 12V/4.5A; 19.2V/2.5A; 2.5V/10A 11.50

*½% **5% †10% (REST 1%)

1500	2000	4000	4300**
5000	5100	7500	7950*
10000	15000	17000	30000
50000	75000	100000	130000
140000	147000	166760	201000
229000	250000	950000	.....

"TAB" SPECIAL 3 for $1.00

PRECISION WIRE WOUND RESISTORS, ICR, SHALLCROSS, MEPCO, INST. RES. CO., OHMITE FOR METERS, BRIDGES, AMPLIFIERS.

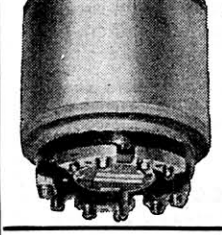
25000	294000	314000	333500
353500	400000	402000	422000
458000	478000	3 for	$1.50
500000	600000	700000 3 for	1.95

1MEGOHM 1% accy 3 for..... 2.45
SPRAGUE 10Meg 10KV MEGOMAX MFA1 ..... $1.75
SPRAGUE 12Meg 12KV MEGOMAX MFA1 ..... 1.95
IRC WW1¼ of 1% H'metcly Sealed Navy Resistors ($24) 1.69

WRITE FOR OTHER SIZES FROM STOCK

STANCOR 355VCT325ma & 490V/325ma; 115V/60c PRI $4.50
CHOKE 50Hy/125ma cased mfgered CHT 2.50
Transf. 10V/25A; 2.5V/5A; 772V/7ma; 115V/60c. 5.50
Raytheon cased 840VCT/110ma; 540VCT/21ma; 5V/3A; 5V/3A; 6.3V/1A; 6.3V/.6A; 115V/60cy Pri & Two 10Hy/110ma Ht'ely cased Chokes & Oil Condsr Two 2.5 & 5mfd/600WVDC.... 8.95
Hmtcly cased choke 10Hy/150ma. Two for.... 3.25

Basic kit 3" C'Ray THORDARDSON 1320V & 750VCT 110ma; 5V/3A. 2.5V/3.25A. 6.3/2.75A. PRI 115V/50-60cy HV ins with High & Low V Rectifier tubes, choke, resistors, Condsrs & 3BP1 tube & socket. New Navy insp. $16.95
Oscilloscope manual TS-324 DUMONT/241 Detailed data ..... .69
PRI-TRANSF 230V inpt. 117/112/103/93V/7AMP GE 19.95
TRANSF 1200VCT/350ma, PRI 105-120V/50-60cy Cased 6.95
STANCOR 2100V/10ma—115V/50-60cy C'RAY 5.95



NEW SELSYNS TYPE XXI AC SYNCHRONOUS 115V

60cy—Made for Gunfire control. Guaranteed Ordnance Insp. Hi-accuracy. Continuous duty. Packed for overseas shipment, complete with Insp. Calibration report.

Per pair **$7.95**

IF YOU DON'T SEE IT—WRITE FOR IT

Crystals 1N21, 22, 23, 25 GTD 4 for..... $1.50
Condsr oil 20 mfd/600WVDC (1-2-4-5-8mfd)... 1.50
LS-3 Perm Mag 6" hvy duty Spkrs (LN)..... 4.95

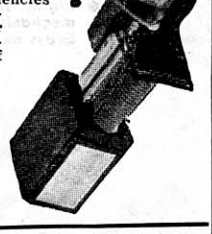
★ ★ ★ ★ ★ ★ ★ ★

$2 Min. order FOB N.Y.C. Add Postage all orders and 25% deposit. Worth 2-7230. Send for catalog 300. Specialists in International Export, School, College & Industrial trade. Money Back Guarantee.

ANTENNA A-27 (PHANTOM)

New in metal box with calibration card 2 to 4.5mc's; useable as dummy antenna load frequencies to 28mc's contains Variable Xmitting Cardwell or Millen Type 12515 condenser 18 to 175mmf ($7.50) Easily converted to Split Stator & 2 Ward Leonard plague resist Non Ind 12ohm/40watt incl. Manual & Spare leads.

SPECIAL **$1.95**



"TAB" • DEPT. RN3, 6 CHURCH ST., NEW YORK 6, N. Y., U. S. A. • "TAB"

Corner Church and Liberty Streets, Room 200

plications, of various portions of the radio frequency spectrum. He has been associated with the Bureau of Standards intermittently since 1929, having been granted leaves of absence to serve with the FCC and the War Department.

—30—

Sound Recording

(*Continued from page* 92)

harmonics of a fundamental tone are generated at different intensity levels. This may be compared in a sense to higher resonant modes of a vibrating mechanical system and their general effect is to reduce fidelity of the original tone.

There is a definite phase effect existing between the sound wave and generated harmonics in the ear and the effect contributes to the distortion experienced in hearing. As may be expected, there are definite intensity limits between which speech and music are reproduced with perfect fidelity.

There are many factors affecting the quality of a tone. Among these are the harmonic content, pitch, and intensity. The *quality* of a tone is also called *timbre* and should be distinguished from *fidelity*. Timbre is a relative quality of sound while fidelity is a true measure of the accuracy with which a sound is reproduced. While much has been done in measuring timbre, the results are subjective. "Fullness," "richness," "brassy," "metallic," are some of the terms used in describing the timbre of a sound.

(*To be continued*)

What's New in Radio

(*Continued from page* 78)

50 db. below 1 volt dyne/ cm² open circuit.

Designed in an attractive combination of black molded plastic and satin chrome finish, this high impedance unit can be used with any amplifier or recorder employing high impedance input. The microphone is supplied complete with an 8 foot cable, plug and removable base which allows conversion from a desk to hand mike at will.

The Brush Development Company, 3405 Perkins Avenue, Cleveland 14, Ohio will supply additional data to those who ask for it.

COMBINATION RADIO

Air King Products Company, Inc. has recently introduced its new table model radio-phonograph combination, "The Crown Princess," to the trade.

Designated as the Model 4704, this unit is styled with simple dignity which fits into any decorative scheme, modern or period. This model comes in satin walnut finish accented by an edge-lighted dial, and features an automatic record changer for ten and twelve inch records, a featherweight low-pressure tone arm, permanent

Nationally Known **AUTOMOBILE ANTENNAS**

Side Cowl—3 Section 66" Sturdy, Rust Proof
$4.75 LIST $2.13 NET

Deluxe Side Cowl—4 Section 100" Sturdy, Rustproof
$7.45 LIST $3.36 NET

Top Cowl (Fender Mount) — 3 Section 56"
$5.95 LIST $2.58 NET

Universal Cowl or Fender Mount—3 Section 68"
$5.95 LIST $2.58 NET

All are complete, ready for installation.
All are chrome-plated.

VIBRATORS — Standard 4-Prong, $1.40 each.
10 FOR $12.50

CONDENSERS—.005 mfd. 1200 V DC Buffer Condensers
19 CENTS EACH—10 FOR.....$1.50
100 FOR $12.50—1000 FOR..$100.00

STANDARD DISTRIBUTOR AND SPARK PLUG SUPPRESSORS
17 cents each 10 for $1.50 100 for $12.50
STANDARD VIBRATOR TRANSFORMERS.....$0.98 each

CROWE REMOTE CONTROL AUTO HEADS
For All Makes, All Years...$3.82 each
Tone Controls ..... 1.71 "
Volume Controls ..... .73 "

SPECIAL—SPECIAL—SPECIAL
St. Clair Vacuum Tube Voltmeter — 6 DC Voltmeter Ranges—6 AC Voltmeter Ranges—Ohmeter Range from 0.1 Ohms to 1000 Megohms—Accuracy 2% Plus or Minus
FORMERLY $52.50, NOW $42.50

A COMPLETE LINE OF TUBES ARE NOW AVAILABLE

Write for Our Latest Catalogue

RADIO PARTS COMPANY
612 W. Randolph Dept. "N" Chicago 6, Illinois

HEXACON ELECTRIC SOLDERING IRONS

..tagged for the big jobs!

TYPE P-150 (illustrated)



Follow the leaders—and use HEXACON! For rugged, heavy duty work or for light intricate work . . . here's the answer. One reason is "Balanced Heat"—dissipating excessive element-impairing heat—and minimizing element burn-outs and tip replacements. Another is their lightweight. Literature is available describing the complete HEXACON line of screw tip and plug tip irons from 40 to 700 watts, and with tip diameters ranging from ¼" to 1¾".

HEXACON ELECTRIC CO.
119 W. Clay Ave., Roselle Park, N. J.

HIGH-QUALITY, LONG-LASTING SOLDERING IRONS

HEXACON

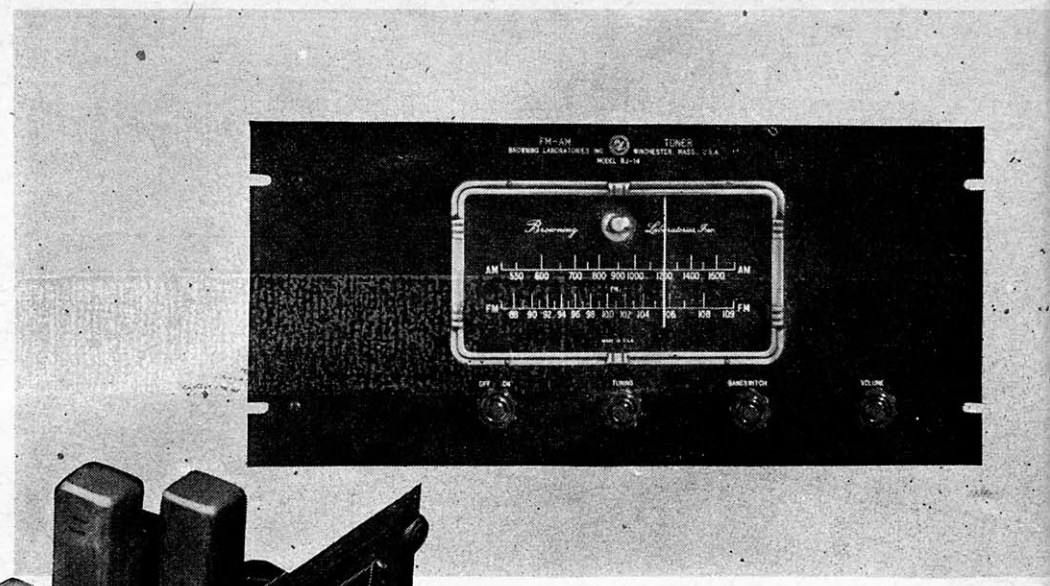


Fig. 1. The Browning RJ-14 (top) and the RJ-12 (bottom) tuners represent two of the many different makes of commercially built, high quality tuners that may be used for recording off-the-air programs.

Part 10. Covering a discussion of two representative tuners, well suited to recording radio programs directly off-the-air.

By OLIVER READ
Editor, RADIO NEWS

The Recording and Reproduction of Sound

ONE of the major requirements for the recordist is a good high quality tuner for picking up signals from local transmitters and, in particular, for purposes of recording high quality music or other entertainment on his discs, etc. The requirements permit latitude in the selection of a tuner as we may begin with a simple two or three tube job employing tuned r.f. circuits, and later procure one of the universal FM-AM tuners, such as the one to be described, when we wish the ultimate in FM-AM reception for recording purposes or public address installations.

Such tuners include the *Browning* RJ-12 and RJ-14, Fig. 1, which are designed for high fidelity reception in the 88-108 mc. FM band as well as the standard AM broadcast band. This tuner is designed for maximum performance when used with a 300-ohm FM antenna. Almost any commercial FM antenna having this impedance should work satisfactorily. It is important that no part of the antenna system be grounded because of the balanced feed required on FM operation. On AM operation, the entire antenna and feeder act as the antenna. The antenna system should, therefore, be located as high as possible. For those who wish to build their own antenna, a drawing has been provided to furnish the necessary information. See Fig. 3.

Shielded leads from the tuner to the recording amplifier are essential. When making up the cables, the center conductor should be stripped, tinned and inserted in the center sleeve of the male connector and heated until the solder flows, making a good joint. It is well to bring the braid up on the outside shell of the plug and solder all the way around. There are some cases where the shield on the lead between the audio output of the tuner and the amplifier employed may not be a sufficient ground bond between the two. In cases where there is any hum, not present in the amplifier itself, bonding of the amplifier and tuner with copper braid of No. 16 or larger wire, should be used.

The power requirements for the tuner are 250 volts d.c. at 65 milliamperes and 6.3 volts a.c. or d.c. at 4 amperes. Occasionally the voltages are available from the recording amplifier. If these voltages are not available, a separate power supply should be used. A schematic diagram of such a unit is incorporated in the diagram Fig. 5.

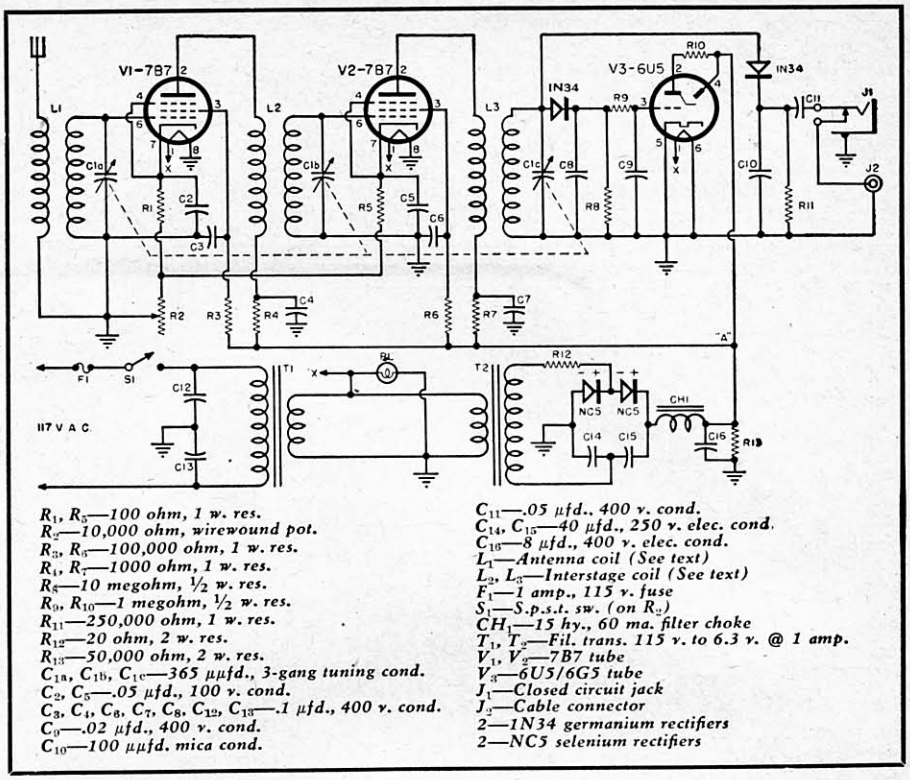
The FM section of the tuner employs the famous Armstrong circuit. In the r.f. portion we find several new miniature type tubes (Fig. 5), a 6BA6 r.f. amplifier, a 6BE6 mixer, and a 6C4 triode oscillator. Following the mixer are two i.f. amplifier stages that operate at a center frequency of 8.25 mc. Excellent gain is realized in the r.f. stage and in its conversion to the intermediate frequency amplifier. In order to obtain the most effective

quieting, two limiters are used in cascade. Assuming that proper limiting is used, then the major source of distortion in FM circuits lies in the nonlinearity of the discriminator characteristic. When this curve of frequency versus output voltage is linear over the range of modulation, there can be no distortion in detection. This tuner has an excellent linear characteristic. High frequency pre-emphasis, purposely introduced at the transmitter, must be compensated for in the tuner if we are to obtain a linear output voltage. A suitable high frequency attenuator compensates for the standard degree of pre-emphasis which is inserted at the transmitter.

The superheterodyne circuit employed in the AM section has one r.f. stage and one i.f. stage. It further employs a diode detector to provide audio and a.v.c. voltage. A sensitivity of one microvolt or better over the entire band is made possible by employing recently developed tubes. The bandpass of the i.f. amplifier provides a high selectivity much desired for average interference-free reception. Noise reduction benefits are realized due to this selectivity and yet the quality of reproduction remains excellent.

One of the features of this commercially built tuner is the insertion of a wave trap that is tuned to 450 kc. to provide a low impedance path to ground for any signal that might otherwise cause interference. This is to eliminate local high power, low frequency code stations in particular.

Especially designed recording amplifiers will be described in later chapters. They are well suited for use in conjunction with the *Browning* tuner as well as the simple home-made tuner to be described in the following paragraphs.



R_1, R_3—*100 ohm, 1 w. res.*
R_2—*10,000 ohm, wirewound pot.*
R_3, R_6—*100,000 ohm, 1 w. res.*
R_4, R_7—*1000 ohm, 1 w. res.*
R_5—*10 megohm, ½ w. res.*
R_9, R_{10}—*1 megohm, ½ w. res.*
R_{11}—*250,000 ohm, 1 w. res.*
R_{12}—*20 ohm, 2 w. res.*
R_{13}—*50,000 ohm, 2 w. res.*
C_{1a}, C_{1b}, C_{1c}—*365 μμfd., 3-gang tuning cond.*
C_2, C_5—*.05 μfd., 100 v. cond.*
C_3, C_4, C_8, C_7, C_8, C_{12}, C_{13}—*.1 μfd., 400 v. cond.*
C_9—*.02 μfd., 400 v. cond.*
C_{10}—*100 μμfd. mica cond.*
C_{11}—*.05 μfd., 400 v. cond.*
C_{14}, C_{15}—*40 μfd., 250 v. elec. cond.*
C_{16}—*8 μfd., 400 v. elec. cond.*
L_1—*Antenna coil (See text)*
L_2, L_3—*Interstage coil (See text)*
F_1—*1 amp., 115 v. fuse*
S_1—*S.p.s.t. sw. (on R_2)*
CH_1—*15 hy., 60 ma. filter choke*
T_1, T_2—*Fil. trans. 115 v. to 6.3 v. @ 1 amp.*
V_1, V_2—*7B7 tube*
V_3—*6U5/6G5 tube*
J_1—*Closed circuit jack*
J_2—*Cable connector*
2—1N34 germanium rectifiers
2—NC5 selenium rectifiers

Fig. 2. Schematic diagram of a home-built, three-tube, t.r.f. tuner. The unit covers the AM broadcast band and is suitable for recording purposes.

T.R.F. Tuner

A high fidelity radio frequency tuner suitable for use with a recording amplifier or public address system may be constructed from parts readily available in the average junk box. The tuner to be described was designed by *E. Bruce Pray, Engineer, Electronics Division, Sylvania Electric Products, Inc.*

In addition to its being useful for recording or in conjunction with large permanent p.a. and paging systems (such as are installed in factories, clubs and parks), the radio tuner may be coupled to all types of portable amplifiers such as small truck amplifiers and record players.

The tuned r.f. circuit is well suited to recording applications because of its inherent low distortion. The latter is obtained at somewhat of a sacrifice of tuning—the tuning ordinarily tending to be broader than in a standard superheterodyne. However, the tuned r.f. section may be engineered to have good selectivity, as well as fidelity. Another outstanding advantage is the fact that the tuned r.f. "front end" picks up less noise interference than many of the low-priced sharper tuning superhets.

This tuner has been designed for maximum selectivity rather than maximum amplification, and consists of two transformer-coupled pentode tubes, feeding into a germanium diode rectifier acting as the detector.

It is often of great importance that an r.f. tuner introduce as few additional tubes as possible. Here, we have handled this situation by employing a germanium crystal diode as the detector, and a selenium unit as the separate power supply rectifier. The rectified audio signal is delivered to an output jack located on the rear of the chassis, and to a headphone jack located on the front panel. This arrangement enables the operator to monitor the tuner ahead of the amplifier into which it feeds. This is a convenience, especially during tuning-in periods. The final radio frequency signal is also fed to another germanium rectifier, the output of which is filtered and fed to the grid of an electron ray indicator tube.

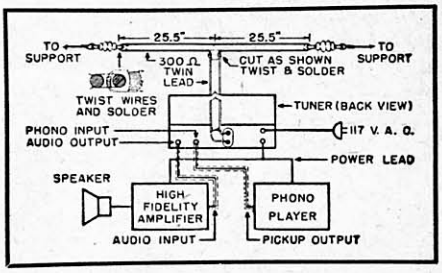
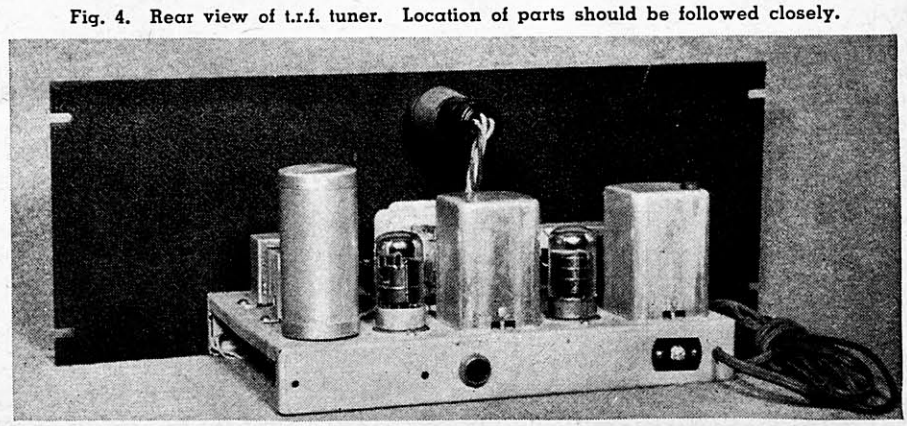


Fig. 3. Diagram shows installation wiring of an FM-AM tuner. Details for antenna construction are also given.

This second crystal unit serves to clear up the eye image, giving a sharper pattern than ordinarily would be obtained.

The power supply operates from a 115 volt, 60 cycle source and consists of two 6.3 volt, 1 ampere filament

Fig. 4. Rear view of t.r.f. tuner. Location of parts should be followed closely.



transformers with their secondaries connected together. The junction of the two secondaries is used to supply the filaments of the amplifiers, while the output of the combination, approximately equal to the line voltage, is fed to two selenium rectifiers connected as a voltage doubler. This back-to-back transformer arrangement permits use of the line voltage without the dangerous ground-return common to a.c.-d.c. line power supplies. At the same time, tube heater voltage is supplied without having to incorporate line-cord resistors.

The additional plate voltage supplied by the voltage doubler results in higher output and greater sensitivity than would be obtained with only 115 volts on the plates of the tubes.

The output ripple of the voltage doubler combination is reduced to a minimum by the addition of a 15 henry filter choke and an 8 μfd. condenser. The 50,000-ohm bleeder resistor completes the power supply which will be more hum-free than either a series-filament arrangement or an a.c.-d.c. transformerless supply.

Layout is an extremely important factor. The first decision that must be reached in constructing electronic equipment is that of proper location of parts, and selection of a suitable chassis. This, at first sight, might appear to be wasted effort, but after rebuilding a unit several times, one then fully realizes the importance of proper parts location.

The amplifier employs a 7"x11"x1½" chassis and a standard 7"x19" panel. Above the chassis (Fig. 4) are located the tuning condenser, the two filament transformers, the three shielded r.f. transformers, the two tubes, the filter choke, and the magic eye.

The transformers and choke are mounted together and in such a way that their fields do not interfere with the tuning condenser (C_1). The tubes and coils are arranged across the rear of the chassis, with the antenna coil at the extreme left hand corner, followed by the first r.f. amplifier, the first r.f. coil, the second r.f. amplifier and the second r.f. coil. Locate the magic eye on the front panel directly over the dial.

In mounting the tube sockets (Fig. 6), arrange each one so that its grid contact is nearest to the coil connecting to the preceding stage. The plate contact then automatically will be opposite the coil of the following stage. The antenna and ground binding posts should be located at the rear of the chassis, just under the antenna coil.

Locate the two selenium rectifiers on the front of the chassis by means of two machine screws inserted through the mounting eyelets which are insulated from the discs. Caution should be exercised to avoid grounding the discs of the rectifier. These discs carry the a.c. potential, and a short circuit at this point might damage the filter condensers, the rectifiers, or the transformers. The chassis position of these rectifiers should always be such that they are not mounted adjacent to any heat-dissipating components, such as power tubes, high-wattage resistors, etc.

The two germanium crystals are mounted on a terminal strip which is placed along the left hand edge of the chassis. All grid and plate leads should be as short and direct as possible, and the plate leads kept close to the chassis.

(*Continued on page* 106)

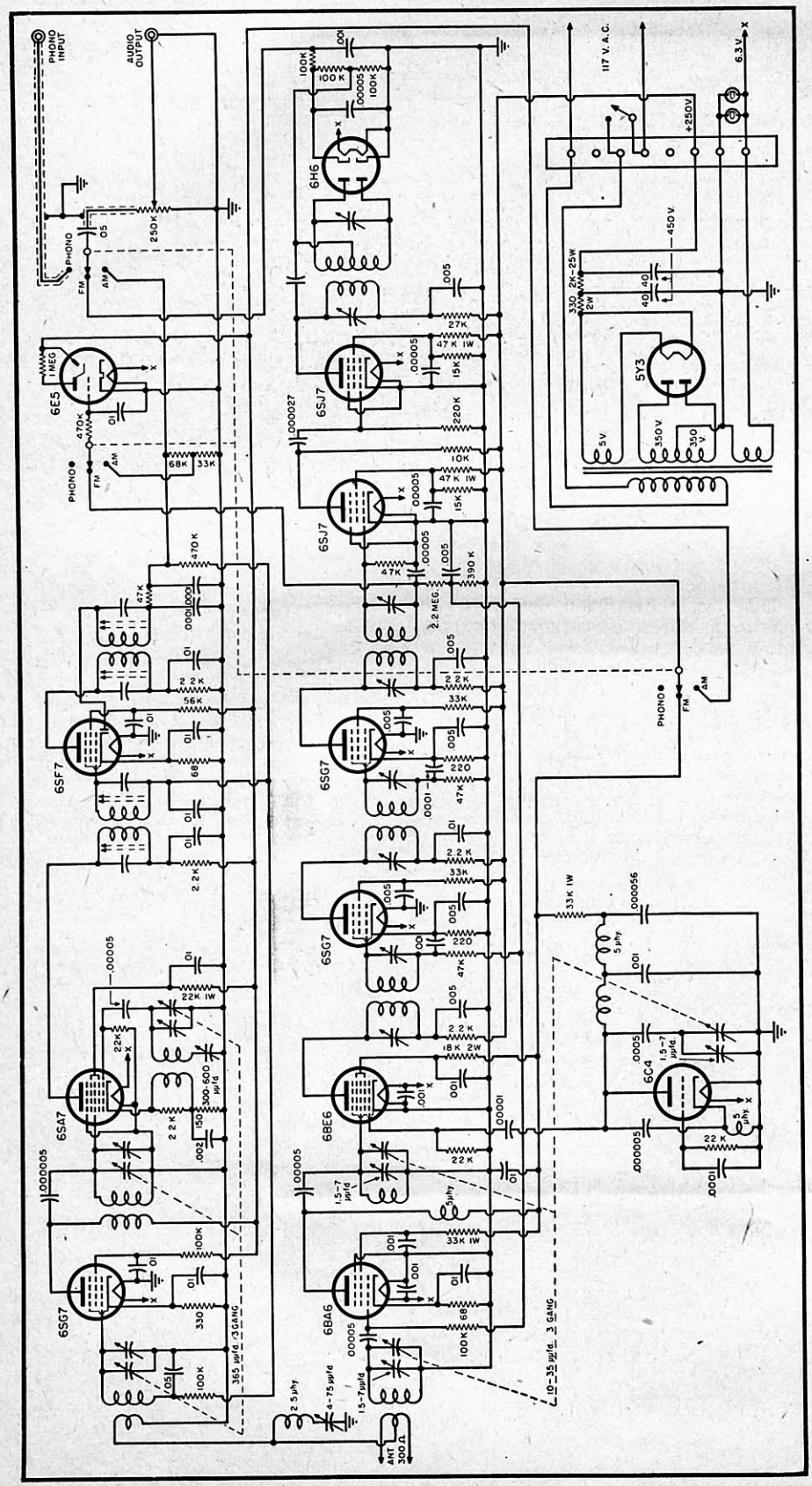
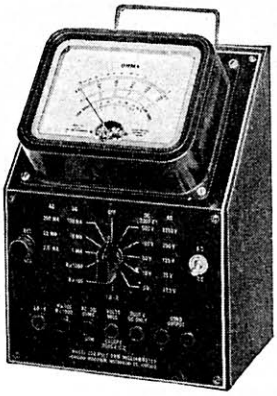


Fig. 5. Complete schematic diagram of Browning Models RJ-12 and RJ-14 FM-AM tuners. The power supply which is incorporated in this schematic diagram is actually built as a separate unit and connected via cables.

Chicago INSTRUMENTS

Quality at Low Cost!







For years, Chicago Instruments have given radio men accurate, dependable service. And because of simplicity of design and freedom from "gadgets" we have been able to hold down prices to a fraction of what you would normally pay for instruments of similar quality.

POCKET VOLT-OHM-MILLIAMETERS FOR ONLY $5.25

Anyone can now own a good volt-ohm-milliammeter. There is a Chicago V.O.M.A. priced at only $5.25. Chicago "Featherweights" that slip easily into the pocket are the original miniature radio test instruments. They are popular throughout the world.

Chicago Instruments are available in a variety of ranges and sensitivities. You may see them at your Suppliers or get the complete details by writing for Bulletin No. 10.

CHICAGO INDUSTRIAL INSTRUMENT CO., 536 W. ELM ST. CHICAGO 10, ILL.

G-C

Dial Belt Kits
Ne-O-Lite Tester
Alignment Kit
Phono Turntable Stand

G-C SERVICEMEN'S DIAL BELT KITS



Easy to install. The best belts for all sets. Supplied in kits of assorted popular belts with steel box. No. G-25 — Kit of 25 belts. List.....$6.70

G-C NO. 5024 ALIGNMENT KIT



Complete alignment and neutralizing kit of 30 different tools, in leatherette case. List.....$19.95



G-C PHONO TURNTABLE STAND

Steel stand on which you can place any phono turntable; ideal for repairmen; easily adjusted; sturdy steel construction. No. 5205—List.....$6.65

G-C NE-O-LITE TESTER



For testing fuses, appliances and any electrical circuits. 90 volts to 550 V., A.C. or D.C. No. 5100—List.....50c

Available at all leading distributors

WRITE FOR YOUR CATALOG TODAY!

RADIO DIVISION, DEPT. H

GENERAL CEMENT Mfg. Co., Rockford, Ill., U.S.A.
Manufacturers of over 3,000 products
Sales offices in principal cities

Radio Parts Distributors

SENSATIONAL VALUES!

Nationally Known Brand

8" PM SPEAKER.....$2.89
5 for.....$13.75
10" PM SPEAKER.....3.25
5 for.....$15.50

100 Ass't

½ Watt Resistor Kit.....$1.69

5BP4 Television Scope Tube.....$3.79

CONDENSER SPECIALS

10 mfd.,	25 V.	23c—10 for	$1.90
20 mfd.,	150 V.	34c—10 for	2.75
40 mfd.,	150 V.	38c—10 for	3.10
8 mfd.,	450 V.	34c—10 for	2.75
16 mfd.,	450 V.	50c—10 for	4.10
20-20 mfd.,	150 V.	59c—10 for	4.70
20-30 mfd.,	150 V.	68c—10 for	5.40

500M Controls with Switch.....Ea., 59c
10 for.....$5.50

We carry a full line of tubes, batteries, speakers, amplifiers, test equipment, hardware, controls, etc.

FREE! Write for R.P.D.'s latest bulletin for more sensational Values!

Terms: Remittance with order plus postage or 25% deposit, balance C.O.D.

Radio Parts Distributors
925 E. 55th St., Chicago 15, Ill.

Recording of Sound

(*Continued from page* 50)

The on-off toggle switch, pilot lamp, phone jack, and sensitivity control are all mounted on the front panel. All other miscellaneous parts, such as bypass condensers, resistors, etc., are mounted as close to their respective circuits as possible in order to reduce interaction between stages and avoid unnecessary troubleshooting after the completion of the unit.

The location of the two 7B7 lock-in tubes makes interstage shielding unnecessary. However, if the reader employs some other layout, especially a non-metallic chassis and panel, interaction (and feed-back) may be experienced. If this does happen, it will be necessary to mount an upright sheet-metal baffle between the power supply components (transformers and chokes) and the tuning condenser and other r.f. components. Interaction usually is noticed first at the high frequency end of the dial. Most readers will prefer to buy factory-made r.f. coils (both the antenna and interstage units) rather than winding them at home, since such manufactured coils may be obtained quite readily and are reasonably priced. They are designed to have a high Q and are completely adjusted. Several manufacturers supply these coils already mounted in shield cans of the proper size. Those readers having an assortment of shield cans may use the unshielded coils. However, one must bear in mind, when shielding an r.f. coil, that the smaller the diameter of the shield in respect to the diameter of the coil, the lower will be the Q, and consequently a lower gain will be experienced. A diameter ratio of approximately two-to-one and a length ratio of one and one-half-to-one is recommended.

The filaments of the tubes and the panel lamp should be connected to the 6.3 volt section of the transformer combination, using twisted leads to insure freedom from 60 cycle hum. These leads should be dressed close to the chassis, as far as possible from grid or plate leads. The reader must not forget to ground one heater terminal to the chassis by means of a short, direct connection.

The use of inexpensive 1 ampere filament transformers as the power transformer was made possible by the use of dry disc rectifiers, which have no filaments to draw current. It is a good practice to connect the primary of the improvised power transformer to the line, and check the filament circuit for voltages, before completing other power supply wiring.

The two line bypass condensers (C_{12} and C_{13}) aid materially in elimination of line hum, and these units must not be excluded.

The screen grids should be wired with a 100,000-ohm, 1-watt resistor (R_3-R_6) in series with the positive side

(*Continued on page* 110)



END OF YEAR SPECIALS

RADIO HARDWARE TREASURE. Approx. 1000 screws, nuts, washers, lugs, etc. for many radio needs.....$0.49

ALNICO MAGNETS
Powerful ALNICO MAGNETS in many sizes and shapes always in stock. Write for latest fully descriptive illustrated supplement.

UTC "OUNCER" INPUT TRANSFORMERS (⅞"x1¼"). Dynamic mike or low impedance pick-up to grid.....ea. $0.49
12 for..... 5.00



EXPERIMENTAL TUBES. 20 asstd. receiving types for testing, research, etc. Fil. tested...$1.00

3" MAGNETIC SPEAKER for Majestic portables or general replacement...$2.25

HANDY RADIO PARTS KITS
#2—SPEAKER CONES; 12 asstd. 4" to 12" moulded and free-edge (magnetic incl.). Less voice coils.....$2.00
#3—MOULDED BAKELITE CONDENSERS; 50 asst. .00001 to .2 mfd. 200-600 WV. Clearly marked.....2.95
#4—TUBULAR BY-PASS CONDENSERS; 50 asstd. .001 to .25 mfd. 200-600 WV. Standard brands.....2.49
#8—KNOBS; 25 asstd. setscrew, spring and push button. Wood and bakelite.....98
#10—VOLTAGE DIVIDERS; 10 asstd. multi-tapped. High wattages included.....1.98
#20—SPEAKER REPAIR KIT. Save time and money with this professional kit. Contains: 25 paper rings, 25 voice coil forms, 10 spiders, 3 yds. felt strips, 20 chamois leather segments, kit of 16 shims and tube of cement..2.49
#27—PRECISION RESISTORS (Weston, Shallcross, etc.) ±1% wire-wound. 10 asstd. ohmages to 400 K.....1.98
#28—ROTARY SELECTOR SWITCHES. Six asstd. standard makes. Incl multi-deck and ceramic insul.....1.75

TUBES: Perfect condition, but not in sealed cartons. Most types in stock at up to 80% off list. Every tube guaranteed 90 days.
#20, 27 46 or 56.....$0.29
#42, 45, 75, 76, 77, 78, 80, 89, 5Y3, 6H6 or 6K7.....39
#35, 36, 37, 39, 84, 5Y4, 6C5, 6F5, 6J7, 6N7, 6U7, 6SA7, 6SK7, 12SA7 or 12SK7.....49
#1A7, 1H5, 1N5, 1R5, 6U5, 6X5, 7A7, 7C5, 7C6, 7Y4 or 50.....59
TUBE CARTONS: Plain white.
GT size (1¼" sq. x 3¼").....Per 100 $1.25
Medium size (1½" sq. x 4¼").....Per 100 1.49
Large size (2" sq. x 5").....Per 100 1.79

RCA VICTOR POWER TRANSFORMER for models R-32, 45, 52 or 75. Unshielded.....$5.95

VARIABLE CONDENSERS. 2 gang, 365 mfd. Ball bearing shaft; O.D. ⅜"x¾".$0.75

BENDIX AMPLIFIER (Line of Sight) 115 V. 400 cycle. Contains: power trans., 3 audios, 6 oil condensers, plus other components worth many times the price. Black crackle finish case. 7"x5¾"x4" Shpg. wt. 9 lbs.....$1.95

CRYSTAL MICROPHONE UNITS. Famous make, sensitive diaphragm type. Small size (1¾" O.D., ¼" deep) ideal for REGULAR or CONTACT MIKE or PILLOW SPEAKER. Rubber shock mtd. metal frame. Less housing.....$0.69

AUDIO TRANSFORMERS—3:1, DC. Resist.: 800/7000. Hermetically sealed. 2x"1⅛"x 1½".....$0.69
LINE TRANSFORMER (intercom., P.A., phone, etc.) Impedance: Pri. 250 ohms; Sec, 8 ohms with 5 equal taps, —16 to 0 db. 2" O.D., 2½" high.....69

6 V. TELEGRAPH KEY AND BUZZER (W.E.). Fully adjustable platinum contacts. ¼" bakelite base.....$1.25
Key only.....39

Get on our mailing list—Always something new!

PROMPT SERVICE ON ALL SPEAKER AND PHONO PICK-UP REPAIRS
Minimum Order $2.00—20% Deposit Required on All Orders. Please Add Sufficient Postage. WRITE DEPT. RN-12

LEOTONE RADIO CO.
MAKERS OF CONES AND FIELD COILS
65-67 DEY STREET. NEW YORK 7, N.Y.
WORTH 2-0284-5
12,000 SQ FT OF RADIO PARTS

of the power supply. A .1 μfd. condenser (C_3-C_6) should be connected between the screen grid and ground, to bypass to ground all fluctuations resulting from the radio frequency action on the electron stream inside the tube. This r.f. fluctuation, were it allowed to reach the d.c. power supply, could easily produce oscillations or other unwanted disturbances in the amplifier.

Plate circuit connections should follow, and it is well worth emphasizing again, that plate leads should be kept close to the chassis. The incorporation of the two resistor-condenser plate filters (R_1-C_1 and R_7-C_7) aid substantially in reducing interaction between stages.

The cathode circuit should now receive our attention and the two 100-ohm bias resistors (R_1-R_5) should be connected between the cathodes of the tubes and the 10,000-ohm potentiometer (R_2) which is used as a sensitivity control. The two condensers C_2 and C_5 should be connected between the cathodes and ground to smooth out the r.f. fluctuations.

The germanium diode is furnished with tinned pigtails, and no soldering precaution is necessary other than that which one would exercise in connecting a resistor.

The power supply should present no problem other than the correct connections to the selenium rectifiers. The positive terminal of the *Sylvania* NC5 rectifier is marked *"CATH."* It is from this terminal that we get the positive d.c. output. Normally, these rectifiers are used directly from the power line but in our voltage doubler application complications will be introduced with respect to grounding of the chassis, etc. The use of two filament transformers connected as previously explained overcomes this problem, as well as supplying an isolated source of filament voltage.

Testing

Assuming that the wiring has been in accordance with the schematic diagram (Fig. 2), we are now prepared to test the unit. This testing can be successfully accomplished using a good volt-ohmmeter and a signal generator. More advanced testing can be performed using an oscilloscope and an electronic voltmeter.

The signal generator need only cover the broadcast band (550 to 1600 kc.), since the tuner employs no i.f. amplifier. Should the reader not have access to a test oscillator of any kind, broadcast station carriers may be used conveniently. It is best to select three stations, one near the lower end of the broadcast band, one near the middle, and one near the high end. For this testing only, use the shortest antenna which will deliver good signals.

The reader should allow ± 10% tolerance on all resistance or voltage measurements mentioned in the paragraphs which follow, unless otherwise stated. Step 1 in the testing and calibration program is a resistance check of the power supply. Connect the ohmmeter from point "A" (Fig. 2) to chassis. The resistance should be 50,000 ohms. Should the reading obtained be in excess of the ±10% allowed, check the filter condenser C_{16} for a shorted condition, and the bleeder resistor R_{13} for an open condition.

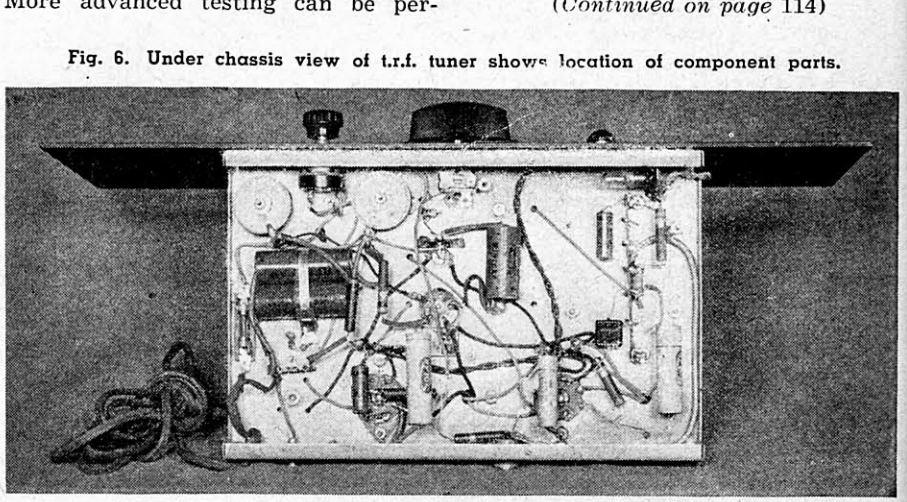
Connect the primary of the power supply to the 115 volt line and test voltages present at the filament of the tubes. This should be 6.3 volts. Having satisfied ourselves of the presence of the correct filament voltages, attention should be transferred to the plate supply. The d.c. voltage present at point "A" should be 250 volts, and at both plates should be 240 volts. The screen grid terminals should measure 100 volts.

We are now ready to apply our test signal. Connect a pair of high impedance headphones to the phone jack. Connect the output of a 400 cycle modulated r.f. generator to the antenna and ground posts of the tuner and adjust the frequency of the generator to 1500 kc. Also rotate R_2 of amplifier fully clockwise. The moving contact arm should now be located at the end of the potentiometer which is connected to the 100 ohm cathode bias resistors. If this is not so, change the end connection.

Rotate the tuning condenser (C_1) until the rotor plates are located at minimum capacitance (completely

(*Continued on page* 114)

Fig. 6. Under chassis view of t.r.f. tuner shows location of component parts.





More Economical



Cannot Tangle



Longer Playing Time

Now Available! 8 HOURS OF CONTINUOUS PLAY ON THE MAGNETAPE* RECORDER!



Now — record and play back on this amazing instrument any sound that can be heard, and many that cannot — from a concert hall symphony, to the beat of your heart. Simple interchangeable capstans provide a choice of three tape speeds for high fidelity, medium fidelity, or up to 8 hour voice recording. The ideal recorder and playback unit for home, office, industry, and broadcast station.

Write today for our free illustrated technical catalog featuring our complete series of Magnetape Recorders and accessory equipment. Send 25¢ in stamps or coin for our new booklet, "Elements of Magnetic Tape Recording — and 999 Applications."

* Trademark

30 Second Rewind





Quieter Operation

Easy Editing



Improved Response Range



Complete Automatic Erasing



AMPLIFIER CORP. of AMERICA

398-2 Broadway, New York 13, N. Y.

"You can really solder with a G-E Handy Iron"



George ReQua, hobbyist and home craftsman.

THAT'S what Mr. ReQua says about his G-E Handy iron. "It gives fast, continuous heat, lets me solder rapidly," he states. "It's ideal for the average repair job around the house. The more I use it, the more I like it."

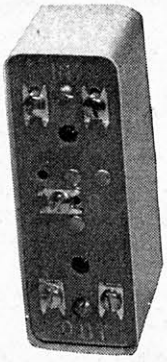
Mr. ReQua has reason to like his Handy iron. For it has same design as G-E industrial irons, yet is lightweight, easy to use, built to last. See the G-E Handy iron at your dealer's today. If your dealer does not have them order direct, giving us your dealer's name. *Dept. D667-4, Apparatus Department, General Electric Company, Schenectady, N. Y.*

Free: *"How to solder" manual with every iron.*

GENERAL ELECTRIC 667-4K

THE SIMPLEST

FM CONVERTER



Converts 40-50Mc FM Tuners and receivers to 88-108Mc operation. Simple to attach and adjust. No power required. Hundreds now in use all over U.S.

Model 1002A List $10.00

FM INTERFERENCE TRAP FOR TELESETS

Models 1002A 1005A

Eliminates FM and amateur interference from tele image by absorption of interfering signal. Two adjustments provide for elimination of signals in 80-115Mc and 40-60Mc Ranges.

Model 1005A List $10.00

CRYSTAL CONTROL FOR FM TV AND BC RECEIVERS

Send 25c (no stamps) for booklet describing applications of quartz crystal control for local oscillator of your home receivers.

See Your Local Parts Jobber or write for information

CRYSTAL DEVICES CO.

1819 Broadway, NEW YORK 23, N. Y.

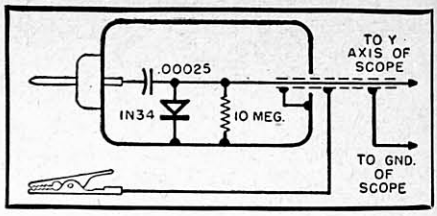


Fig. 7. The r.f. probe.

open). Adjust output of the signal generator until a signal is heard in the headphones. To adjust the amplifier, vary the trimming condensers located on the main tuning condenser C_1 until the signal is loudest. As the signal increases above the comfortable listening point, reduce signal strength by lowering the output of the signal generator. In cases where a radio station carrier is used in place of a signal generator, the signal strength may be reduced by shortening the antenna wire.

More advanced readers may adjust the unit with the aid of an oscilloscope. The amplitude of the wave represents the measured voltage output and at the same time the distortion of the amplifier may be visually inspected. To do this properly, proceed as follows:

Step 1. Connect output of signal generator to the antenna-ground input of the amplifier.

Step 2. Connect ground of scope to chassis of amplifier.

Step 3. Connect generator, scope, and amplifier to line and warm up for 15 minutes to stabilize these units so that accurate measurements may be taken.

Step 4. Connect the circuit shown in Fig. 7 in series with the *Y* axis input of the scope and the antenna ground of the amplifier, and note the audio waveform on the scope. Inasmuch as this represents the output of the generator, the reader will have an excellent source of comparison as we poceed with our stage-by-stage visual alignment.

Step 5. Transfer the probe to the grid of the first 7B7 tube and note the waveform and voltage gain on the scope. An amplification of about 1.5 should be experienced.

Step 6. Transfer the probe to the plate of the first r.f. tube, adjust the trimmer of the first stage tuning condenser C_1 until the amplitude of the waveform present on the screen of the oscilloscope reaches maximum. This waveform should be the same shape as that noticed directly from the generator. If any noticeable distortion of this waveform is experienced, readjust R_2. If readjusting R_2 does not clear up the defect, check R_1 for correct value of resistance and check C_2 for either an open or shorted condition. Another possible source of distortion is that C_3 may be open. This would most likely cause oscillation and reduce the stage gain. This distortion procedure also holds true for the second r.f. stage.

Step 7. Proceed to align and check the next stage of the unit in the same

manner, moving the probe to the plate of the second r.f. tube.

Step 8. To complete the visual alignment, we shall discard the r.f. probe and connect the *Y* axis input of the scope to the junction of C_{10} and C_{11}. The waveform now present on the screen of the scope is that of the audio output from the detector. The waveform at this point should be comparable to that witnessed at the first and second r.f. stages. The trimmer on the third stage tuning condenser (C_1) should be adjusted for maximum amplitude.

Step 9. With the scope connected as in *Step 8,* readjust the three trimmers of the tuning condenser C_1 for maximum output. The over-all gain of the amplifier at 1000 kc. is approximately 1200.

Although the tuner described is sensitive enough to pick up strong signals with a random length of wire, we strongly urge the use of the best possible antenna. For maximum efficiency, a long wire, well insulated, and mounted outdoors as high in the air as possible, is recommended. A simple single wire is entirely adequate.

(*To be continued*)

Signal Generator
(*Continued from page* 59)

upon the setting of the *"Modulation"* panel knob (R_{30}) at power line frequency rate, thus eliminating the need for special synchronizing conditions between signal generator and oscilloscope.

As a result of this frequency modulation action, the output signal is varied above and below its center frequency. The fixed oscillator signal is proximity mixed with the variable oscillator output. Because of the heterodyne action, the output frequency delivered by the signal generator is any possible combination of 40 megacycles plus and minus the frequency to which the main dial is set. (For example: When the main dial is set to 10 mc., frequency modulated outputs are obtained at 30 mc. and at 50 mc. The first is 40—10 mc.; the second, 40+10 mc.) To determine the dial setting required for any center frequency needed for FM alignment, it is only necessary for the operator to add *or* subtract the desired frequency mentally to (or from) 40 mc., and then to set the main dial of the generator to *either* this sum or difference frequency. Either one of these settings will give output on the desired center frequency.

The range of frequency-modulated center frequencies delivered by the Model 906 is 90 kc. to 210 mc.

The unit becomes an emergency beat-frequency audio oscillator when the main dial is tuned to the vicinity of 40 megacycles. (With *"Modulation"* switch set to FM, and sweep width set to zero). This is because the heterodyne beat note between the fixed- and variable-frequency oscil-

TELEVISION

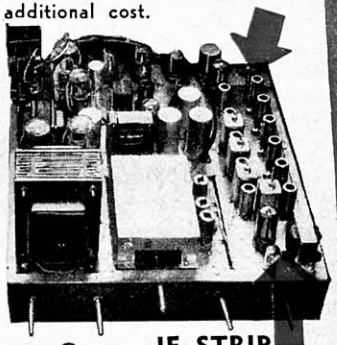
Sensational ASSEMBLY UNIT



For the first time — a 10" Flat Surface Screen Picture unit available in assembly form. This is not a kit but a complete assembly. Picture is 51 square inches.

Also available

A 12" Screen picture, 75 square inches, at a slight additional cost.

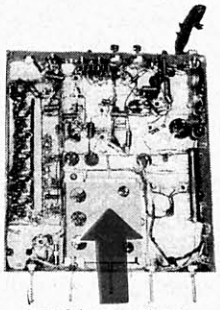


Superior performance is obtained with a new IF Video & Sound Strip (pat. pend.), aligned, wired, pretuned tubed and tested. All the above circuits are contained on one chassis, ready to use when delivered. This unit designed and constructed by engineers. Licensed by Western Electric & Radio Corporation of America.

Easier to operate than your home radio.

IF STRIP

10" FLAT SURFACE
C R TUBE INCLUDED
$229.50
51 SQ. IN. PICTURE COMPLETE WITH ALL TUBES AND COMPONENTS
PRICE F.O.B. OUR FACTORY



FRONT END

ALSO AVAILABLE
12" C R TUBE INCLUDED
$259.50
75 SQ. IN. PICTURE COMPLETE WITH ALL TUBES AND COMPONENTS
PRICE F.O.B. OUR FACTORY

GUARANTEED To operate to your satisfaction when simple directions are followed.

- FRONT END will handle 13 Television Channels. It is so flexible that any number of channels from 1 to 13 can be used. We are now supplying channels 2 - 4 - 5 - 7 - 9 - 11 - 13 with this front end. Install the other channels as desired. Aligned and tested, ready to use when delivered. Merely connect B plus, filament and output I.F. leads to the television chassis. It is not necessary to make any R.F. alignments.
- 29 RCA Tubes included plus 10" flat faced CR tube or 12" CR tube
- Heavy Duty RCA 6.8 oz. slug 12" PM speaker
- Specially designed dipole antenna with 60 foot lead in.
- 4.5 mc band width for greatest picture definition.
- Approximately 10,000 volts second anode potential for better contrast and brightness.
- 5 IF pictures stages
- 2 sound IF stages with Limiter and Discriminator
- High fidelity obtained with FM sound reproduction
- Overall chassis size 17"x19"x3"
- Complete pictorial and schematic diagrams supplied with assembly
- IF frequency — Audio 21.6 Picture 26.1
- Only nationally advertised components used in our assembly.

TERMS: 10% WITH ORDER — BALANCE EXPRESS COLLECT

TELEVISION ASSEMBLY CO. 540 BUSHWICK AVE. BROOKLYN 6, N. Y.

The RECORDING and REPRODUCTION of SOUND

Part 11. Design details for building a high quality record-reproduce amplifier

By
OLIVER READ
Editor, RADIO NEWS

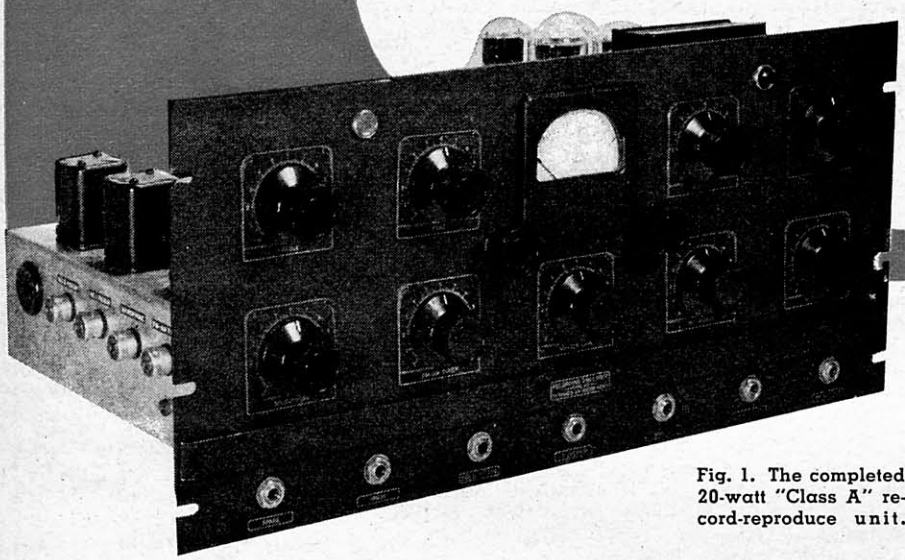


Fig. 1. The completed 20-watt "Class A" record-reproduce unit.

OPINIONS vary among engineers as to the desirability of employing beam power amplifiers instead of triode amplifiers such as the 2A3, 6A3, 6B4, etc., for high quality recording in the output stage of a power amplifier. It is not the purpose of this article to debate pro or con on this controversial subject but rather to point out the advantages and disadvantages of both amplifiers. It is the writer's personal opinion, based on actual experience, that a properly designed output stage employing the type 2A3 triode is a bit superior to the 6L6 even when the latter employs feedback in its output channel. When more than one triode is used, the system becomes even more flexible. Push-pull 2A3's, for example, in self bias operation are capable of approximately 10 watts output at low distortion. The power may be doubled by employing push-pull parallel 2A3's. There is more than one advantage to be gained from this latter arrangement as the plate impedance presented at the primary of the output transformer is reduced to a very low value. When connected to a 500 ohm cutter at the output of the transformer, a near perfect match may be realized due to the extremely low plate impedance of the primary.

Reproducing systems, too, are critical as to their loading. If a 500 ohm speaker is used at the output for reproduction, then the 500 ohm load reflected to the low impedance primary becomes more or less non-critical. Impedance changes with frequency. The closer the match between the primary and secondary, the more non-critical becomes the loading effect. Therefore, high fidelity may be achieved at very low distortion in the output channel.

This is extremely important when driving a 500 ohm magnetic cutter.

First we will discuss a more or less conventional amplifier design which has achieved considerable popularity and is almost the unanimous choice of sound equipment designers. Beam power tubes, as was previously pointed out, are considered desirable for general purpose amplifiers but their high effective generator impedance results in relatively critical requirements with regard to load impedance. The development of degenerative feedback networks indicates a solution to this problem. If a careful choice is made in the output transformer, then it is possible to design amplifiers using push-pull 6L6's in carefully designed circuits which possess negligible intermodulation distortion. The simple amplifier illustrated in Fig. 2 employs such a design. The power output section of the circuit includes two 6L6's in push-pull.

Most manufacturers operate these tubes in Class AB_1 rather than in Class A. The reason for this is that the power supply may be made smaller inasmuch as less static plate current flows. The tubes may be driven harder and more output power obtained at reasonably low harmonic distortion. There is a disadvantage, however. The tubes must be carefully balanced for optimum results. Intermodulation distortion results from non-linearity and it is to be expected that any departure from Class A operation will be undesirable from this standpoint. In Class A, variations in replacement tubes are not as serious as in Class AB_1 operation.

It is very important that the output transformers have adequate inductance. If insufficient, this appears as a shunt reactive load. A reactive load line is elliptical and will combine with the resistive load line to produce an elliptical departure from the linearity. This reduces the undistorted power output. If required, however, a reduced primary inductance may be employed to aid in lowering the bass resonant peak characteristic of beam power tubes fed into a loudspeaker load. Under these conditions there will also be a high frequency rise. This will tend to increase the harmonic distortion percentage. As the impedance rises with frequency, it produces a greater output at harmonic frequencies than at the fundamental frequency. Feedback circuits, therefore, will aid somewhat by providing superior fidelity at the higher frequencies.

There are many types of phase inverters that provide reasonably satisfactory results. The one employed in this circuit is perhaps the most popular. The principal disadvantage in such

a circuit is that the tube stage offers very little gain. This must be compensated for by additional gain in other stages. The difference between the plate circuit-to-ground and the cathode circuit-to-ground shunt capacitance is not the same. This will introduce some unbalance at frequencies above 6000 cycles. However, phase shift problems are greatly minimized and the stability of this circuit is excellent.

A disadvantage of this circuit is that the high cathode-to-filament voltage may introduce some problems that preclude the use of this phase inverter in stages preceding the driver. It is recommended that a resistor of approximately 50,000 ohms for the plate and cathode loading resistors be used. The lower values keep the cathode-to-filament voltage low. The resistors shown in series with the two grids of the 6L6's are not found, as a rule, in commercial amplifiers. They do, however, aid in decreasing tendencies toward oscillation and provide a slight cushioning effect when the 6L6's are driven close to the grid current region.

There is no bypass condenser used across the cathode resistor of the 6J5 phase inverter. The usual bypass should be omitted in order that no hum be introduced in the stage.

It is desirable to use a feedback voltage from one of the plates of the 6L6 or from one of the taps on the winding of the output transformer, if a single-ended amplifier is to be used. It should be pointed out that in such applications feedback in this section of the amplifier should never be used for frequency compensation or for the elimination of hum or distortion which usually results from careless design. Any amplifier should always be constructed without any feedback and adjusted for lowest possible hum and proper performance before any additional circuits are added to introduce any form of feedback. The principal advantage in such a stage is to help to adjust the impedance actually presented by the loudspeaker. Feedback in such circuits will tend to clear up whatever distortion and inherent noise remains. This, however, should be accepted as a secondary advantage and not as a principal design factor.

It is far better to run the feedback from one of the taps on the secondary of the output transformer. Excessive feedback is a bad condition and can only be corrected by cut-and-try by moving the feedback connection to a point of lower output voltage. For the initial adjustment, for choice of feedback components, the amplifier should be run in its normal condition for some time and carefully studied. Then an input voltage from a signal generator should be applied to produce a sufficient signal output for convenient measurement. The secondary remains opened during this test. The voltage is measured directly across the open leads of the secondary of the output transformer. Later a resistance corresponding to half of the correct

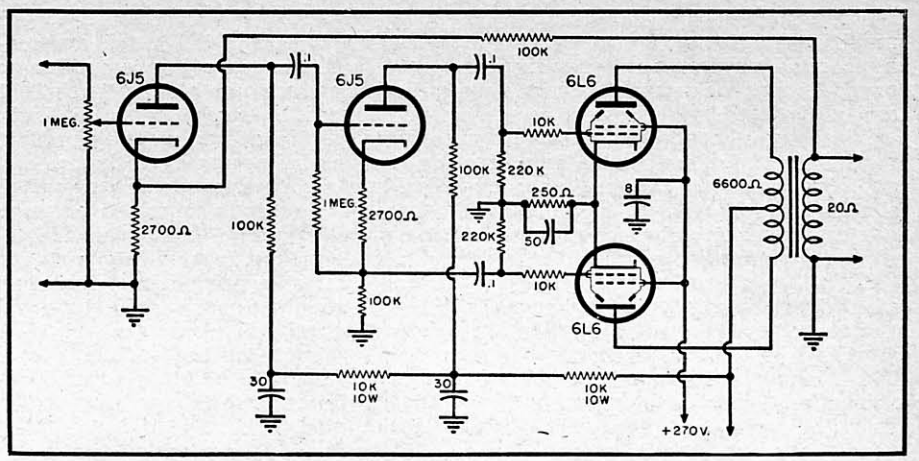


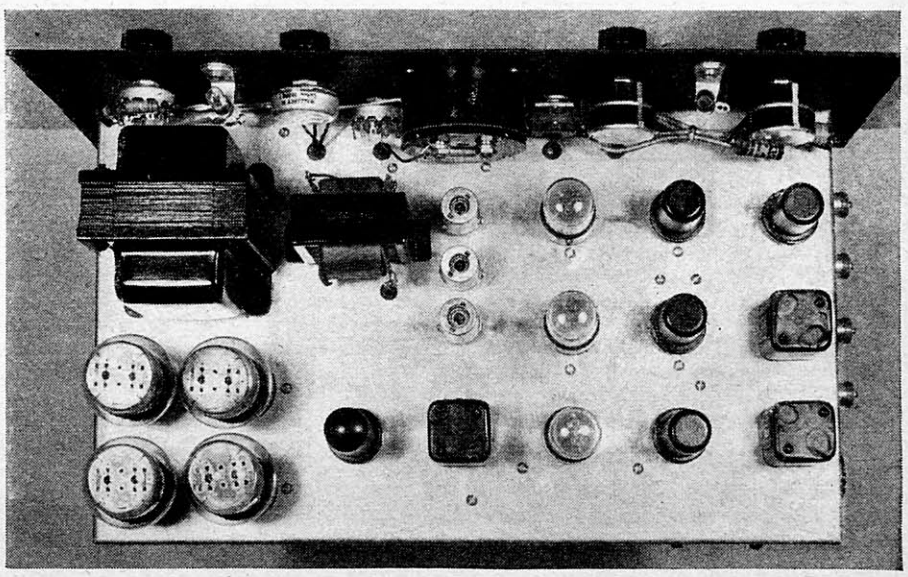
Fig. 2. The 6L6 push-pull amplifier of proven value and good design.

speaker load is applied across the output terminals without changing the input signal. The resulting reduced output is measured on the meter. Usually the voltage will be approximately one-fourth or even less when the resistive load is added. The next step is to take a resistor of approximately 50,000 ohms and insert this in the circuit. By cut-and-try the point will be found where not only is the volume reduced but distortion and other inherent noises will be found to clear up considerably. The ear is the best judge of the correct tap or value of series resistance to be used. When properly adjusted, the actual effective impedance as seen by the speaker will be half of the speaker's nominal impedance. Inasmuch as the turns ratio is a fixed value, the load reflected into the primary of the transformer remains at the desired value.

Note that the use of feedback as a frequency equalizing media is entirely satisfactory in voltage gain stages. However, in the power output stage, the primary purpose of feedback is to stabilize the circuit with regard to variations in speaker or cutter impedance with frequency. We may also take the feedback from the 500 ohm tap of the secondary of the transformer. As mentioned previously, the only rule of thumb for satisfactory operation is to select a tap or voltage point where results are most pleasing to the ear. If too much voltage is taken from an output circuit, oscillations will occur and serious distortion will result. The only solution is to find a point where a lower voltage is present.

We have described briefly a simple circuit employing beam power tubes in the output. It has been the author's experience that when designing an amplifier specifically as a combined record-reproduce unit that an advantage is had by employing triodes in the output stage. Many engineers will argue against this choice but we herein present a design which we feel meets all of the necessary requirements of a good high fidelity recording system. It is foolproof in operation and, while a bit costly to produce, it is capable of performing in continuous duty and offers extremely low distortion, excellent regulation, and a flexibility that is of prime importance in any recording-playback system.

Fig. 3. Top view showing placement of principal components. The three miniatures are employed in a noise suppression circuit. See text.



The amplifier to be discussed is the result of many months of research and affords the maximum in flexibility for sound-on-disc or magnetic recording and playback.

A reserve of audio power is always needed in order to handle excessive audio peaks found in symphonic music. Lacking a reserve, no amplifier can reproduce these peaks without serious distortion being introduced.

Hum-free operation is a prime requisite in a recording system, hence the use of d.c. for the filaments of the preamp, mixer, and tone control tubes. The filaments are wired in series as shown and each is bypassed with a 20 μfd. electrolytic. It is advisable to wire the tubes in the sequence shown for lowest possible hum. There is no audible hum whatsoever in this amplifier with the gain controls wide open.

The complete amplifier (less power supplies) is assembled and wired on a standard 10″ x 17″ x 3″ steel chassis. The power supply is assembled as a separate unit and is located approximately 4 feet from the amplifier to further reduce hum pickup that might be induced by stray magnetic fields. Heavy cables and connectors provide a link for the necessary voltages.

Four separate inputs are provided. One of these is a combined pre-amp and equalizer for the *G-E* variable reluctance pickup, now widely used for high quality reproduction. Two low impedance inputs, one of 50 ohms and the other of 500 ohms, are provided. The former furnishes sufficient gain for the two *Fairchild* dynamic pickups used in this system—the latter for *Pickerings*.

A jack, J_2 (mounted on the patch panel beneath the amplifier), permits a standard phone plug to be inserted if other than the pickups are to be used in this channel. The author uses this position when feeding a 50 ohm *Turner* 999 dynamic microphone into the channel.

The 500 ohm input is used for two *Pickering* pickups and J_4 is used for feeding in a 500 ohm line, when required.

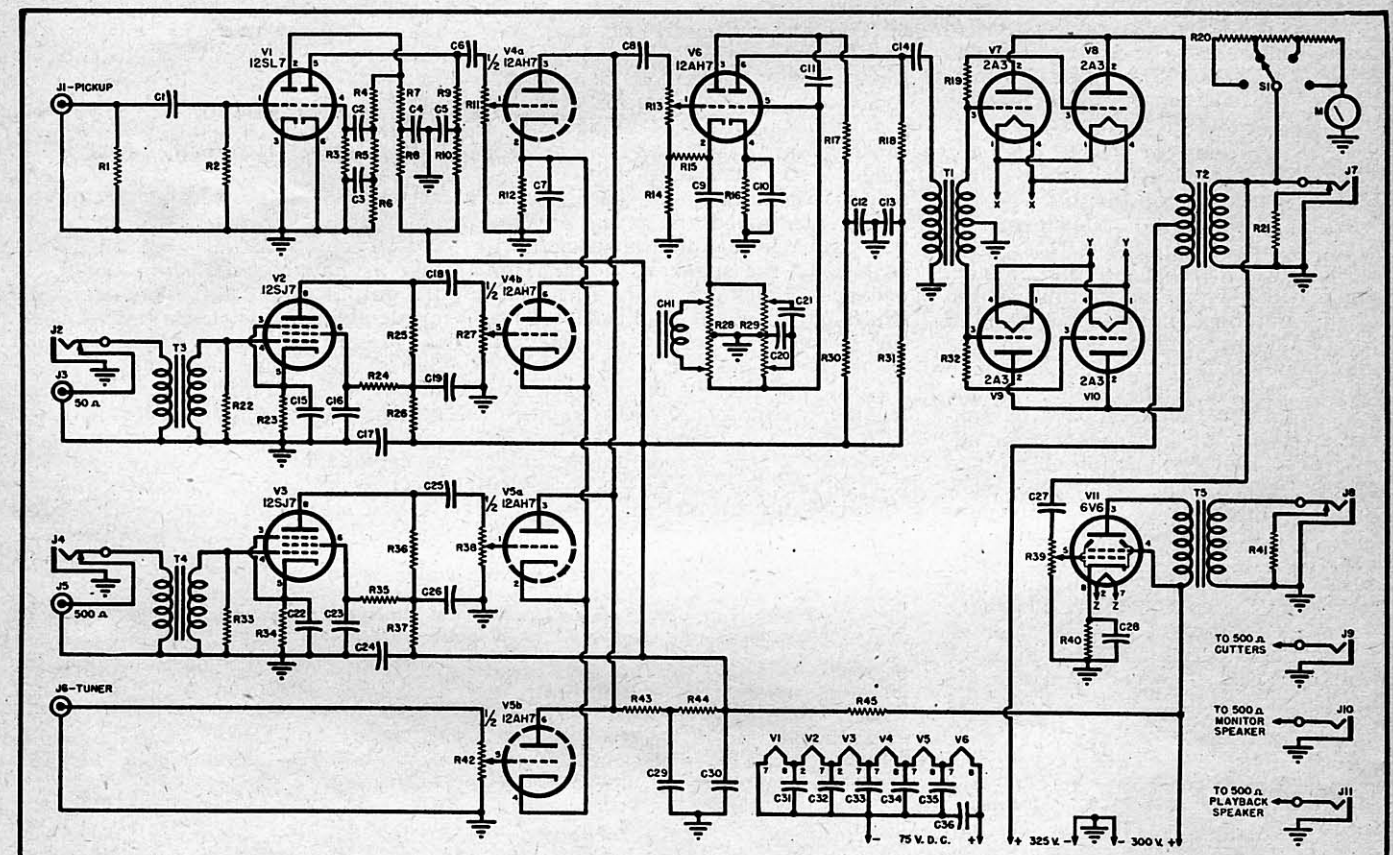
The fourth input is of lower gain and terminates in a *Browning* FM-AM tuner for off-the-air recording. Conventional crystal pickups may also be used in this channel but proper *RC* networks must be added to obtain constant velocity characteristics as described in previous chapters.

Mixing is accomplished within the four halves of two duo-triode 12AH-7's. There is no cross-talk between channels inasmuch as individual grid circuits are employed. All of the plates may be tied together and fed from a common plate load and isolating resistor network, as shown in Fig. 4.

Operation of the equalizer is based on degeneration in the cathode circuit of the first section of the 12AH7. If resistance is introduced in the cathode

(*Continued on page* 166)

Fig. 4. Diagram of amplifier, less dynamic noise suppressor. Power supply is built on separate chassis to offset hum pickup.



R_1—*6800 ohm, ½ w. res.*
R_2, R_3—*3.3 megohm, ½ w. res.*
R_4—*220,000 ohm, ½ w. res.*
R_5, R_{26}, R_{37}—*27,000 ohm, ½ w. res.*
R_6—*180,000 ohm, ½ w. res.*
R_7, R_8—*68,000 ohm, ½ w. res.*
R_9, R_{10}—*33,000 ohm, ½ w. res.*
R_{11}, R_{13}, R_{27}, R_{38}, R_{39}, R_{42}—*.5 megohm pot.*
R_{12}—*470 ohm, 1 w. res.*
R_{14}—*22,000 ohm, ½ w. res.*
R_{15}, R_{16}—*820 ohm, ½ w. res.*
R_{17}, R_{18}—*47,000 ohm, ½ w. res.*
R_{19}, R_{32}—*100 ohm, ½ w. res.*
R_{20}—*Multiplier res. (See text)*
R_{21}—*500 ohm, 20 w. wirewound res.*
R_{22}, R_{24}, R_{33}, R_{35}—*1 megohm, ½ w. res.*
R_{23}, R_{34}—*1000 ohm, ½ w. res.*
R_{25}, R_{36}—*470,000 ohm, ½ w. res.*
R_{28}, R_{29}—*Tone control (Thordarson R-1068)*
R_{30}, R_{31}—*10,000 ohm, ½ w. res.*
R_{40}—*500 ohm, 1 w. res.*
R_{41}—*500 ohm, 5 w. wirewound res.*
R_{43}—*10,000 ohm, 2 w. res.*
R_{44}—*5000 ohm, 1 w. res.*
R_{45}—*4700 ohm, 2 w. res.*
C_1, C_2, C_{11}, C_{14}—*.05 μfd., 400 v. cond.*
C_3, C_{20}—*.01 μfd., 400 v. cond.*
C_4, C_5—*15 μfd., 450 v. elec. cond.*
C_6, C_8, C_{18}, C_{25}—*.05 μfd., 400 v. cond. (in metal can)*
C_7, C_{10}—*10 μfd., 25 v. elec. cond.*
C_9, C_{28}—*10 μfd., 50 v. elec. cond.*
C_{12}, C_{13}, C_{17}, C_{19}, C_{24}, C_{26}, C_{29}, C_{30}—*20 μfd., 450 v. elec. cond.*
C_{15}, C_{22}—*5 μfd., 25 v. elec. cond.*
C_{16}, C_{23}—*.1 μfd., 400 v. cond.*
C_{21}—*.04 μfd., 400 v. cond.*
C_{27}—*.01 μfd., 600 v. cond.*
C_{31}, C_{32}, C_{33}, C_{34}, C_{35}—*20 μfd., 150 v. elec. cond.*
C_{36}—*40 μfd., 150 v. elec. cond.*
T_1—*Single plate to push-pull grids (UTC A-18 or equivalent)*
T_2—*Push-pull parallel 2A3's to 500 ohms self bias*
T_3—*50 ohm to grid (UTC A-10 or equivalent)*
T_4—*500 ohm to grid (UTC A-10 or equivalent)*
T_5—*6V6 plate to 500 ohm line*
CH_1—*Audio choke (Thordarson T-20C74 or T-1C69)*
J_2, J_4, J_7, J_8—*Single closed circuit jack*
J_1, J_5, J_6—*Shielded input terminal jack*
J_9, J_{10}, J_{11}—*Open circuit jack*
S_1—*S.p. 4-pos. rotary sw.*
M—−10 +6 db. meter (See text)
1—12SL7GT tube
1—6V6 tube
2—12SJ7 tubes
3—12AH7GT tubes
4—2A3 tubes

Technicians Everywhere
agree that when
BETTER AMPLIFIERS
are made,
it's A. C. Shaney
who's "a-goin' to make them"

A. C. Shaney, long known as the outstanding designer of high-quality amplifiers, and his associates at the Amplifier Corp. of America, are getting ready to announce the completion of the finest line of public address and political amplifier equipment ever produced. New standards of quality and workmanship, new circuits, new materials, and new manufacturing processes have been combined to make this soon-to-be-announced amplifier line the answer to all requirements. Specifications and performance ratings of these popular-priced models will equal or surpass those formerly found only in high-cost, custom-built equipment. And Amplifier Corp. of America will guarantee every amplifier for 5 full years—an expression of confidence that only the country's leading and most thorough manufacturer of the most modern amplifier designs would dare make.

You can't afford to buy any amplifier until you have investigated the new concept in amplifier design and construction offered by A. C. Shaney and the Amplifier Corp. of America.

Join the many thousands who are "watching and waiting" for the latest in amplifiers from

AMPLIFIER CORP.
of AMERICA

398-2 Broadway, New York 13, N.Y.

A postal card will put you on our mailing list to be among the first to know.

Radio Parts Distributors

SENSATIONAL VALUES!

5" P.M. Speakers.....$1.09
6 for $6.00

Resin Core 50/50 Solder. Size #16 or #11	
5 pound rolls	$ 3.25
5 rolls	15.00
Resin Core 60/40 Solder. Size #23	
5 pound rolls	$ 3.25
5 rolls	15.00

½ Watt Resistor Kits $1.69
500M Controls with Switch ... .59
10 for 5.50

Astatic D7 Pickup
With L70 Cartridge. Each ...$ 2.29
5 for 11.00

CONDENSER SPECIALS

25 mfd	25 V	10 for	$2.30
8 mfd	150 V	10 for	2.05
12 mfd	150 V	10 for	2.60
20 mfd	150 V	10 for	2.75
30 mfd	150 V	10 for	2.95
4 mfd	450 V	10 for	2.60
12 mfd	450 V	10 for	3.30
20-20	150 V	10 for	4.70
40-20	150 V	10 for	5.05
8- 8	450 V	10 for	4.70
16-16	450 V	10 for	8.60

COMPLETE LINE OF TUBES
1 to 24 tubes—40% and 10% off list.
25 tubes and up—50% off list.
Write us for your needs! Prompt Shipment.

HARDWARE
Assortment screws, nuts, washers, rivets, grommets, solder lugs, springs, and 1,000 other useful parts. 5 pounds $1.49.

FREE! Write for R.P.D.'s latest bulletin for more sensational values.

TERMS: Remittance with order plus postage or 25% deposit, balance C.O.D.

RADIO PARTS DISTRIBUTORS
925 E. 55th St., Chicago 15, Ill.

Tommy Kneitel, New York City, these five stations located at Royal Observatory (Greenwich), Abinger Magnetic Station, near Dorkin, Surrey, England: GKU4, 4.025; GKU2, 17.685, GYB8, 19.080; time tick services from 1255-1300 on GIC, 8.640, and GKU3, 12.45. It was also explained that BBC call letters are not used at the microphone but that announcers are instructed to specify frequencies either in megacycles per second in the appropriate meter band, or by reference to the meter band only.

Official QRA of "Voice of America in Manila" is The Department of State, Office of International Information and Culture Affairs, International Broadcasting Division, c/o The American Embassy, Manila, Philippine Islands. (Radio Australia)

VP4RD, *Radio Trinidad*, 9.645 (listed 9.625), Port-of-Spain, Trinidad, has been heard in England at 1700-1800. (Brownless) A Port-of-Spain station on 14.975 has been heard at 1415 contacting VRR4, Kingston, Jamaica. (Legge via NNRC)

KZRH, 9.64, Manila, is reported to recently have been heard announcing the call-sign of its alternate transmitter, KZMB. (Radio Australia).

Acknowledgement

Many thanks for all the FB reports received during 1947. Keep up the good work by sending your reports to Kenneth R. Boord, 948 Stewartstown Road, Morgantown, West Virginia, U.S.A.—K.R.B. -30-

Recording of Sound
(*Continued from page 56*)

circuit, any signal developed by the tube will also appear across the resistance. This signal voltage is opposite in phase and in series with the voltage impressed on the grid and cathode of the tube. Degeneration takes place and the amplification of the tube is reduced. In this application the plate loading resistor, R_{17}, is made small and the cathode resistor, R_{14}, large so that a greater part of the voltage developed by the tube appears in the cathode circuit.

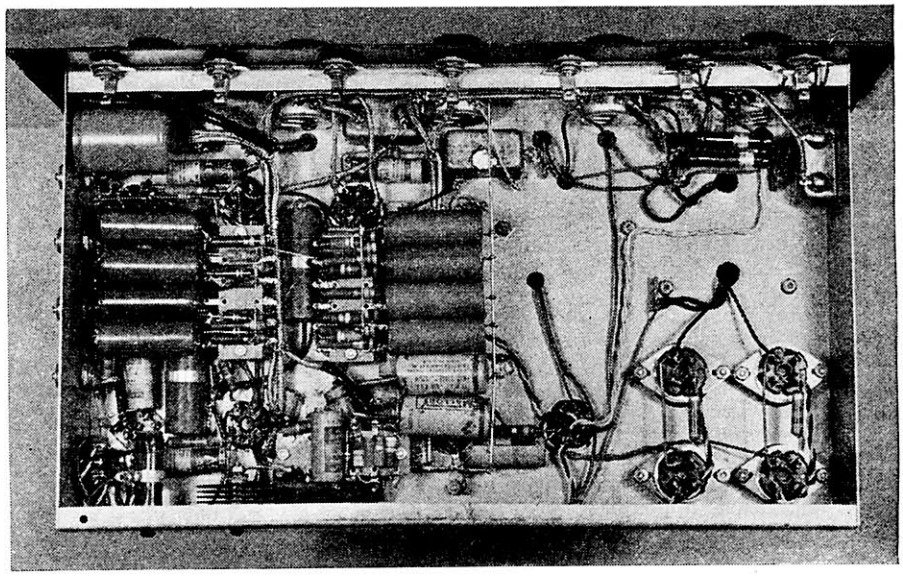
Since the circuit is resistive, there is little or no frequency discrimination at audio frequencies and all frequencies are degenerated in an equal amount. If the cathode resistance is shunted with an inductance of proper value, the resistance at low frequencies is practically shorted out due to the low impedance of the choke at low frequencies. Therefore, degeneration of the low frequencies is eliminated and the greater part of the signal developed by the tube appears across the resistor, R_{17}. The result is an increase in the low frequency response of the circuit.

On the other hand, if a condenser of proper value is shunted across the cathode resistor, the low impedance of the condenser at high frequencies reduces the impedance of the circuit. Degeneration of the higher frequencies is accordingly reduced and the high frequency response of the circuit is increased.

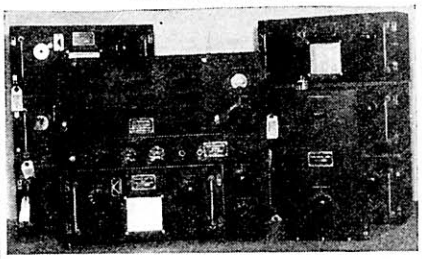
Attenuation of the low frequencies can be accomplished by shunting the grid circuit of the following stage with a choke or inductance. The value of the choke, CH_1, used in the bass boost circuit, also has the correct value for an attenuation circuit. The high frequencies can be attenuated by shunting the same grid circuit with a suitable condenser.

The function of control, R_{28}, is to introduce the choke, CH_1, into either the cathode circuit for bass boost or into the grid circuit for bass decrease. Control, R_{29}, applies condenser C_{21} to the cathode circuit for treble increase or C_{20} to the grid circuit for treble decrease. The controls are coupled to the cathode through condenser C_9 and to the following grid by a shielded lead. Shielding of the choke is ex-

Fig. 5. Bottom view of amplifier showing proper location of all components. The tone control choke is mounted in the upper left hand corner of chassis.



BC 375 E
TRANSMITTER
BRAND NEW



Basic transmitter, complete with seven tuning units 200 to 500 and 1.5 to 12 mc. Antenna tuning unit and technical manual, less tubes and dynamotor. Shipping weight: 275 lbs.

PRICE **$29.50**

BC 375 TRANSMITTER
Same as above with one selected tuning unit **$17.95**

BC 375 & BC 191 TUNING UNITS WITH CS-48 CASE—
TU-5 and TU-6.....$3.00 each
TU-7-8-9-10-26 ..... 2.50 each

BC 306 ANTENNA TUNER $3.00



CORD CD-307
2 conductor; rubber covered, 5½ ft. w phone plug PL-55 one end and JK-26 other end. (JK-26 takes PL-54 Plug.)



CORD CD-318
3 conductor; rubber covered, 7½ ft. long. PL-68 Mic. jack on one end and DPST Palm Switch, momentary and locking, on other end with JK-48 jack. (JK-48 takes plug used with lip mic. T-45 and Throat mic. T-30.)

Price, Cords...39c each—3 for $1.00

0-500 MICROAMMETER
0-15 and 0-600 DC Volt scale, with multipliers **$2.50**

B19 MARK II SETS AND ACCESSORIES—*Write for Prices*

Shipments made F.O.B. Lima, Ohio
25% Deposit required on C.O.D. orders

FAIR RADIO SALES
223 S. MAIN ST. • LIMA, OHIO

AVAILABLE FROM STOCK!



SOLAR
CF-1-60

EXAM-ETER
Combination CAPACITY CHECKER and VACUUM-TUBE VOLTMETER. The *ORIGINAL* instrument which permits:

- Checking of all types of capacitors under load, without disconnecting from the circuit.
- Measures capacity from .00001 to 2,000 mfd.
- Measures leakage current at voltages up to 550.
- Self-contained 600 volt power supply for external breakdown tests.
- D.C.—V.T.V.M. up to 500 volts.
- A.C.—V.T.V.M. up to 50 volts.
- Insulation tester from 3 to 10,000 megs.
- Resistance ranges up to 7½ megs.

Complete with tubes, test leads, and detailed instruction book. **$59.70**

ADSON RADIO CO.
221 FULTON ST., NEW YORK 7, N. Y.

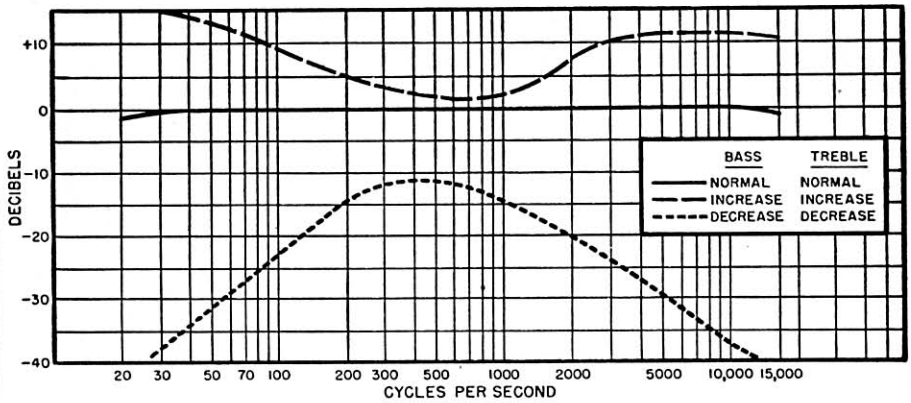
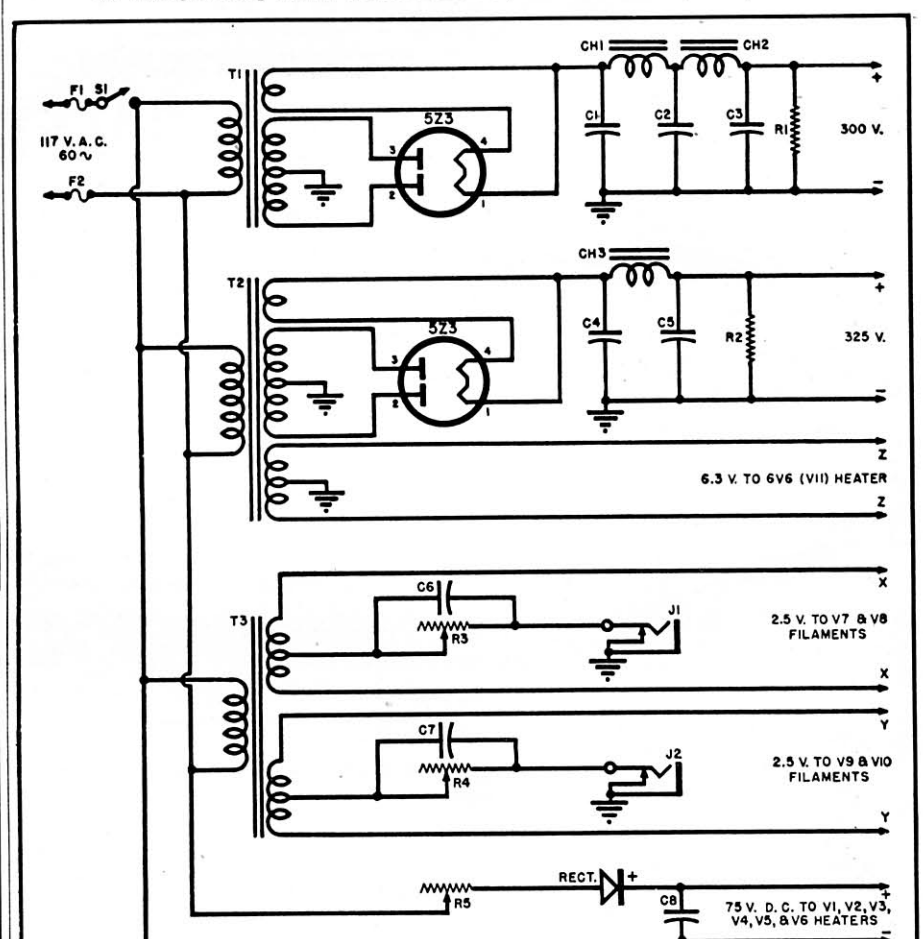


Fig. 6. Audio response curves for various combinations of bass-treble control settings.

tremely important. It must be oriented physically on the chassis for lowest possible hum pickup. In the amplifier described, the best location was found to be under the chassis directly below the tone controls. Shielding must run all the way to the bottom of the choke.

The low frequency control will boost 12 db. at 60 cycles (in the maximum boost position) or attenuate 28 db. in the cut-off position. The high frequency control will boost 12 db. at 10,000 cycles in the maximum boost position or attenuate 35 db. in the maximum cut-off position. This range permits complete tonal balance of the system for all audio applications.

Fig. 7. Schematic diagram of the power supplies. Outputs are fed to amplifier through heavy cable. Plate current may be measured at jacks, J_1 and J_2.



R_1—30,000 ohm, 50 w. res.
R_2—50,000 ohm, 50 w. res.
R_3, R_4—500 ohm, 20 w. pot.
R_5—150 ohm, 50 w. res. (with slider)
C_1, C_2, C_3—8 μfd., 450 v. elec. cond.
C_4, C_5—16 μfd., 600 v. elec. cond.
C_6, C_7—10 μfd., 150 v. elec. cond.
C_8—40 μfd., 150 v. elec. cond.
CH_1, CH_2—Filter choke, 25 hy. @ 100 ma.
CH_3—Filter choke, 10 hy. @ 200 ma.
J_1, J_2—Closed circuit jack
T_1—Power trans. 290-0-290 @ 90 ma.; 5 v. @ 3 amps.
T_2—Power trans. 350-0-350 v. @ 200 ma.; 5 v. @ 3 amps.; 6.3 v. @ 3 amps.
T_3—Fil. trans. 2.5 v. @ 5 amps. c.t., 2.5 v. @ 5 amps. c.t.
Rect.—200 ma selenium rectifier
F_1, F_2—117 v. line fuse
S_1—S.p.s.t. toggle sw.
2—5Z3 tubes

During "sound effects" recording, the author employs the treble-bass cut-offs to simulate the tonal qualities of a carbon telephone. In this position both high and low frequencies are severely attenuated and only the middle frequencies are amplified. Other applications similar to this will be obvious to the reader.

During recording at 33⅓ r.p.m., the high frequencies are greatly accentuated (boosted) to compensate for the reduced velocity encountered when cutting small diameters on a recording disc. This boost is reduced as the cutter travels away from the hub of the disc and approaches the larger diameters with a resulting increase in linear velocity of the whirling disc.

The bass control remains at its normal or mid-setting during recording. If an attempt were made to employ bass boost during cutting, there would be a tendency to over-modulate the record. The result would be distortion in adjacent grooves (crosstalk) or even a cutting through from one groove to the next.

During playback,the process may be somewhat reversed, i.e., a bass boost may be employed and high frequencies may be either attenuated or adjusted to suit the individual listener.

Shielding is of the utmost importance in keeping the over-all hum under control. All grid and plate leads should be shielded as well as the metal can type condensers C_6, C_8, C_{18}, C_{25}. All shielding should run as close as possible to the soldering lugs and the shields should be grounded near the source of signal.

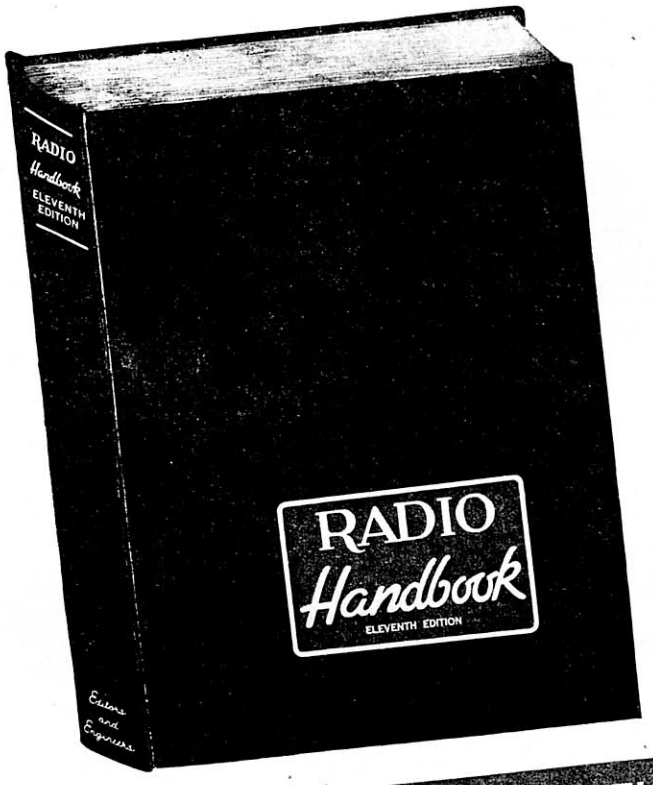
It is highly important to use *only one ground lead* to chassis in the entire amplifier. The best point can be located only by experiment. In the amplifier shown in Figs. 1, 3, and 5 this was found to be at the cathode of the 12SL7.

Special attention should be given to the polarity of all coupling condensers. The outside foil (ground) should in all cases be connected to the point of lowest impedance. In certain cases it might be advisable to completely shield all coupling condensers. A heavy copper wire or braid is also desirable from amplifier to ground.

Bonding via copper bus is sometimes needed between amplifier and tuner.

One of the requisites for accurate recording is an excellent monitor amplifier and speaker so that sounds entering the cutter may be heard simultaneously. It is not considered good practice to shunt a speaker load across a cutter. The load presented by the speaker varies with frequency. This variation disturbs the normal impedance of the cutter. A separate channel is provided, employing a 6V6, which receives its signal from the 500 ohm output winding of T_2. Operating Class *A*, the tube draws no grid current and therefore does not upset or take power from the 2A3's.

A separate gain control, R_{29}, permits individual volume control setting of this channel. The output transformer,



LARGER SIZE
More Detailed Photographs

All new equipment shown. Other sections extensively revised.

Many New Chapters

New larger page size (same size as this magazine) means more material than ever before.

RADIO'S OUTSTANDING PRACTICAL TEXT

The greatest RADIO HANDBOOK ever published. The greatest array of practical radio equipment ever shown between the covers of one book—all brand-new. All newly-designed, and newly-built by practical men, for practical men; all tested in our own shop in actual use.

Featured in this edition

- Dozens of transmitters for all bands, and all powers up to 1 kw.
- Six chapters on Antennas, Transmission Lines, and Propagation.
- One chapter devoted entirely to rotary array construction and feed methods.
- One large chapter on the conversion of widely-distributed military surplus equipment to amateur and other practical use.
- New constructional data on beam-tetrode amplifiers.
- One chapter on determining the operational characteristics of all types of amplifiers.
- New, simple FM exciter designs.
- New data on transmitter control by improved methods.
- New V-F-O design.
- Simplified antenna tuning device and sending-wave meter.
- The most extensive tube tables of any book not devoted entirely to such data.

PER COPY **$3.00** IN U. S. A.
shipping weight 3½ pounds

Clothbound, Gold Stamped, at your favorite dealer's in U.S.A. Mail orders, $3.25 postpaid in U.S.A.; foreign, $3.50 postpaid.

GET IT AT YOUR FAVORITE DEALER'S. If he cannot supply you, you may order direct from us by mail.
DEALERS: "Technical" discounts allowed on this book when purchased by the radio, book, and news trades in quantities for resale.

Editors and Engineers LIMITED 1302 KENWOOD ROAD Santa Barbara CALIFORNIA

1" OSCILLOSCOPE

Anyone can build the world's smallest oscilloscope for less than $15. • Measures 3"x 4"x 5" • Has focus, intensity, X and Y input axis controls • Internal sweep • Simple, easy to understand blueprints and instructions $1.00 pp.

PLASTICS & ELECTRONICS COMPANY
272 Northland Ave. Buffalo 8, N. Y.

RADIO
Technician and Radio Service Courses
FM and TELEVISION
American Radio Institute
101 West 63rd St., New York 23, N. Y.
Approved Under GI Bill of Rights
Licensed by New York State

TEST EQUIPMENT

AUDIO SIG. GENERATOR: 20-20,000 Mfg. by nationally known manufacturers for Lab use with square and reg. sine wave. 12 tube circuit with res. cap. tuned oscillator, direct read dial, res. coupled amplifier sect. w/P-P output, an output, trans. w/var. imp. secondary used for sine wave output, a square wave forming section & amplifier, voltage reg. pwr. sup. 110-220AC. Associated output attenuators. Orig. value $425.00. Surplus Bargain, Never Used **$62.50**

NATIONALLY KNOWN I-56C TUBE CHECKER: set analyzer voltohmeter & cap. checker comb. with output & DC voltohmeter. 3 meters in one carrying case w/adapters & prods. Used, but in excellent cond. Orig. value $139.00. Close Out Special..... **$52.50**

McCONNELL
3834 Germantown Ave., Phila. 40, Pa. RA5-6033

For those who want the best!

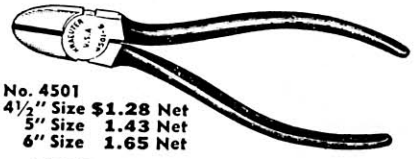
You'll Find it at Resco!

KRAEUTER RADIO PLIERS FOR SERVICEMEN AND AMATEURS

Specially designed for use in all fields of communications and electronics. Blue temper finished handles, polished heads.



No. 1671 6" Size **$2.24** Net



No. 4501
4½" Size $1.28 Net
5" Size 1.43 Net
6" Size 1.65 Net



No. 2612 6½" Size **$2.07** Net

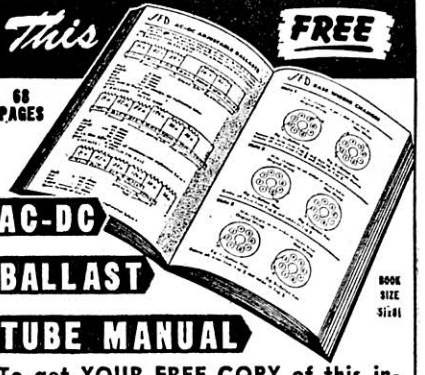
Write for Big New Bulletin—Just Out!

Radio Electric SERVICE CO. OF PENNA., INC.

7TH AND ARCH STREETS, PHILA. 6, PENNA.

Branches: 5133 Market St. and 3145 N. Broad St. in Phila. Also in Wilmington, Del., Easton, Pa., Allentown, Pa., Camden, N. J.

Every Radio Serviceman Needs This FREE



To get YOUR FREE COPY of this indispensable manual (value $1.50) merely mail in to JFD Factory 12 flaps from JFD Radio Dial Belt envelopes; include 10¢ in postage to cover mailing cost. (Buy your JFD Dial Belts and Belt Kits from your nearest parts jobber.)

JFD's new 68-page Ballast Manual is a treasury of information for Radio Servicemen and Dealers — Lists more than 3000 radio ballasts — ACDC Ballasts for Fluorescent lights and electrical appliances — 220 volt to 110 volt Stepdown Ballasts.

Send 12 Envelope Flaps to:

J.F.D. MANUFACTURING CO. INC.

4109-4123 FT HAMILTON PKWAY. BKLYN 19, N.Y.

T_5 terminates in the jack, J_8, so that a speaker or wire recorder may be readily connected. It should be pointed out that patch cords made up from standard shielded phone plugs are used to connect through the various jacks on the panel.

It is important to observe proper polarity in making up the cords. The outside shield in all cases should connect to the outer end of the plug, while all hot leads through the inner conductor terminate in the phone plug tips.

The two load resistors, R_{21} and R_{11}, provide a fixed load across the output transformer secondaries when external speaker or cutter leads are removed. This affords proper loading protection to the transformers.

The meter, *M*, is a standard —10 +6 decibel meter calibrated for use across a 500 ohm line. Suitable series resistors are arranged in conjunction with a multiplier switch to extend the meter range to +24 db. in steps of 6 db. The values of these resistors are dependent upon the individual make of meter used.

The top view of the chassis (Fig. 3) shows three miniature tubes lined up in back of the meter. These are used in the *Scott Dynamic Noise Suppressor* circuit described on page 46 of this issue. The toggle and rotary switches on either side of the meter are also required in the *Scott* circuit.

The reader is urged to follow the layout of all component parts carefully. Failure to do so may result in unsatisfactory performance. All filament wires should be tightly twisted and laced and kept clear of all grid and plate leads. The connector receptacle, shown mounted near the input connectors, was moved to the back edge of the chassis near the 6V6 because of a slight hum pickup caused by the close proximity of the cabling to the input channels. Metal shields were also found to be needed on the 12AH7's.

The chassis is mounted on a standard 7" x 19" steel panel. The jack panel measures 1¾" x 19". The decorative strip was added to enhance the appearance of the amplifier.

The results obtained with this amplifier more than satisfy the most critical listener. Quality comparable to fine broadcast equipment has been achieved and we feel that many readers will want to duplicate this unit.

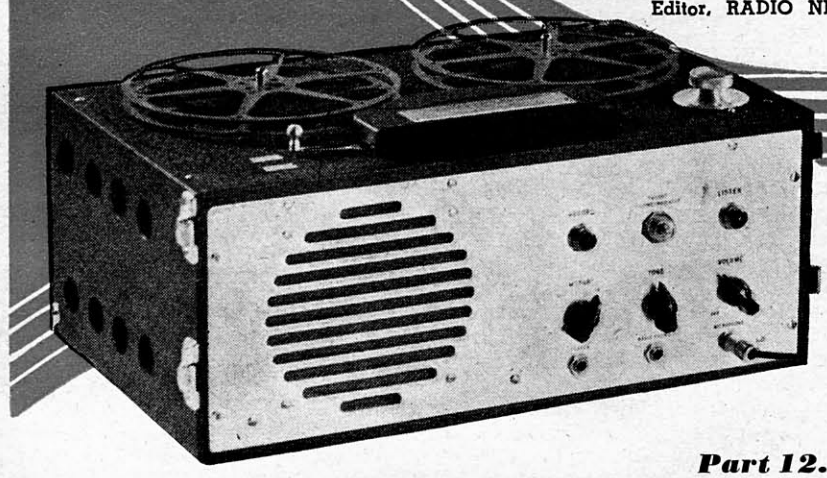
(To be continued)

Engineers for WTMJ-TV, The Milwaukee Journal television station, were erecting the new RCA microwave relay transmitter on the roof of the South Side Armory in Milwaukee, Wisconsin the day this picture was taken. Used for the remote pickup of television programs, this "dishpan" is beamed to a microwave receiving unit installed on the tower at "Radio City" located five miles north of Milwaukee. From this point programs are televised to the Greater Milwaukee area. The new station, which began operation December 3rd, telecasts five days a week, Wednesday through Sunday, for a total schedule on the air of 20 hours per week.



The Recording and Reproduction of SOUND

By OLIVER READ
Editor, RADIO NEWS



Indiana Steel Products' experimental model 5C magnetic tape recorder.

Part 12. An analysis of the mechanical and electrical requirements in the design of magnetic tape recorders.

A MAGNETIC tape recorder consists of three interdependent assemblies: 1, the mechanical unit for moving the tape; 2, the magnetic circuits of the recording and reproducing head in combination with the tape; and 3, the electronic circuits.

Mechanical Requirements

Magnetic tape sound recorders should have a constant velocity drive. This can be best achieved with a wrap-around capstan or pinch roller drive mechanism. Reel drive is undesirable because of the large change in diameter as the reel empties. A constant velocity drive makes editing possible by cutting and splicing.

Magnetic tape sound recorders, like all types of recorders, must be reasonably free from wow. The average ear is very sensitive to two common types of wow, namely, frequency wow and amplitude wow.

Frequency wow is a mechanical difficulty which is present in all types of sound recorders unless special precautions are taken to eliminate it. Frequency wow consists of periodic variation, such as is introduced by gear teeth, eccentricity of mechanical rotating parts, or irregularities in belts, and also by random variations which may result from frictional irregularities.

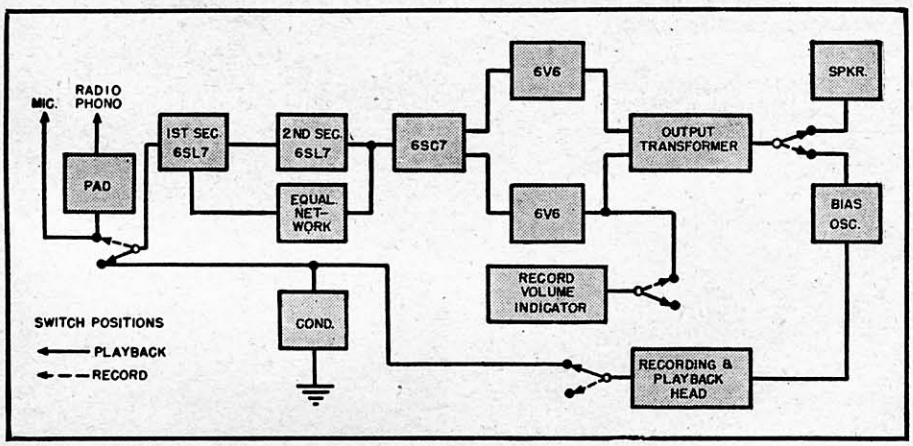
Amplitude wow, that is, the periodic or random variation of loudness, is reduced to a minimum when high quality magnetic tape, such as *Hyflux**, is used, because the coating process used in depositing the magnetic powder on the tape produces a more uniform magnetic member than can be attained by other methods of manufacturing magnetic recording media, and also because the metallic nature of the magnetic powder permits a high degree of homogeneity in the manufactured product.

The solution of the problem of wow in the magnetic recorder is no more difficult than it is in any other type of sound recorder; in fact, the problem is almost identical to that encountered in talking motion pictures, because the recording medium is of similar shape and travels at a comparable speed.

It is difficult to obtain wow-free recording with systems involving gears, especially if heavy flywheels are to be avoided. It is possible to produce specially-cut gears that are wow-free, but in general this is costly and out of the range of a popularly priced unit. Flat belt drives on flat flanged pulleys have been found to be satisfactory because they are relatively free from periodic variations. Round or V-belts generally cause difficulty, because the slightest irregularity in the thickness or stiffness of the belt results in its clinging in the groove of the pulley.

Rubber-tired friction drive wheels

Fig. 1. Block diagram of self-contained portable magnetic tape recorder.



*Trademark of The Indiana Steel Products Company.

have proved very satisfactory, especially for designs in which the rubber drive wheel is subject to little or no contact pressure during the idle periods.

The drive capstan or drive wheel should be directly coupled by a common shaft to a flywheel of as large rotational inertia as practical. The r.p.m. of the drive capstan should be as high as possible, so that a maximum momentum will be achieved. It is quite practical to have the drive wheel as small as three-fourths of an inch in diameter. Experience has shown that the takeup reel may be driven from the shaft common to the flywheel and drive capstan, if the flywheel has sufficient momentum to overcome the random variations of tension on the tape caused by the reeling mechanism. If it is desirable to keep the flywheel size and weight to a minimum, the takeup reel should be driven through a suitable speed reduction device direct from the motor.

The braking and drive mechanism should be so designed that the tape remains under a continuous tension when the direction of the tape is reversed. As the reel size increases, additional braking power is needed. High tensile strength of tape permits the designer a considerable degree of latitude in designing brakes and driving mechanisms. Friction and belt drives naturally provide adequate slippage under extreme loads to minimize the danger of tearing the tape.

As a protective feature, it is desirable that the rewind switch be mechanically linked to the permanent magnet eraser, so that the eraser is automatically thrown out of contact with the tape whenever the machine is rewound. In the design of a machine where the eraser is placed in advance of the recording head, there is no advantage gained by being able to erase during the rewind.

Magnetic Circuits

In the average recorder, it is desirable to use the same magnetic head for recording and playback. Fundamentally, however, the requirements for the two cases are somewhat different and circuit changes are necessary.

In recording, the magnetic member should have high permeability with as small hysteresis losses as possible at higher frequencies. Probably the most important single characteristic of the magnetic material in the recording head is that the material should have as high a magnetic saturation level as possible. A high saturation level is also very important, in order to minimize magnetic distortion and to give the recorder itself a maximum opportunity to have wide dynamic range. In a playback head, extremely high initial permeability is very desirable. The induced magnetic field in the playback head is always small, and high initial permeability will permit the best possible use of this low intensity field. For both recording and playback, the transducer assembly should

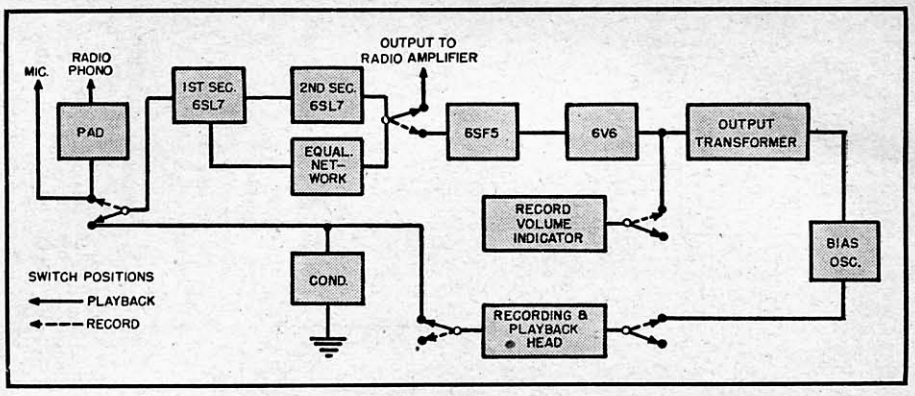


Fig. 2. Block diagram of radio adapter magnetic tape recorder.

have as nearly a closed magnetic circuit as possible, except for the recording gap. For the production of a magnetic head of a laminated structure, it is easiest to fabricate the head as an assembly of two electrically and magnetically equivalent legs with a butt joint. If this construction is used, it is imperative that the joint be fitted as closely as possible.

Experience has shown that the balance of the two legs must be very exact if extremely low pickup is desired in the presence of the comparatively strong stray magnetic field that often surrounds a shaded pole motor. With exactly reproduced layer winding, it is necessary to have the two legs wound with an accuracy of plus or minus one or two turns. If hand-wound experimental coils are used, the variations in induction due to irregular winding may be so great that the number of turns is not a suitable criterion, and the legs should then be wound to a given inductance rather than to a given number of turns.

The width of the recording gap of the head is extremely important. At low magnetic tape speeds it is desirable to have the gap as small as possible in order to obtain a maximum of high frequency resolution along the tape, even though longitudinal magnetization of the tape minimizes stray fields. A gap width of approximately 0.0005-0.002" has proved to be satisfactory.

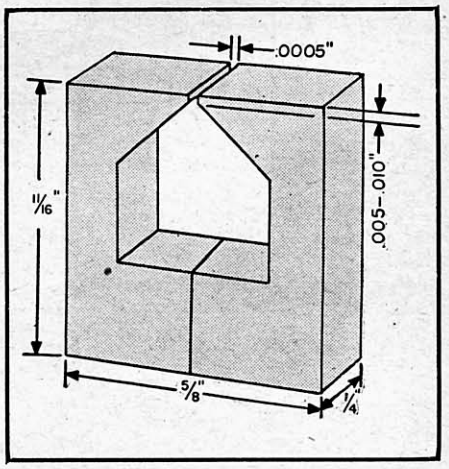
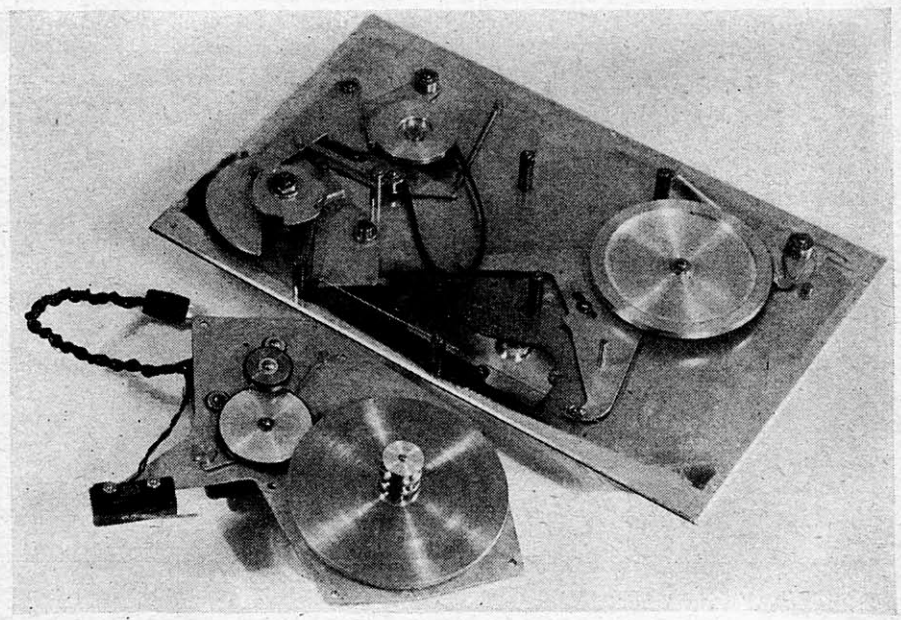


Fig. 3. Mechanical details show construction of record-playback head.

It must be remembered that al-

Perspective view of under side of driving mechanism with motor flywheel subassembly removed. This is part of Indiana Steel Products' experimental model, 5C.



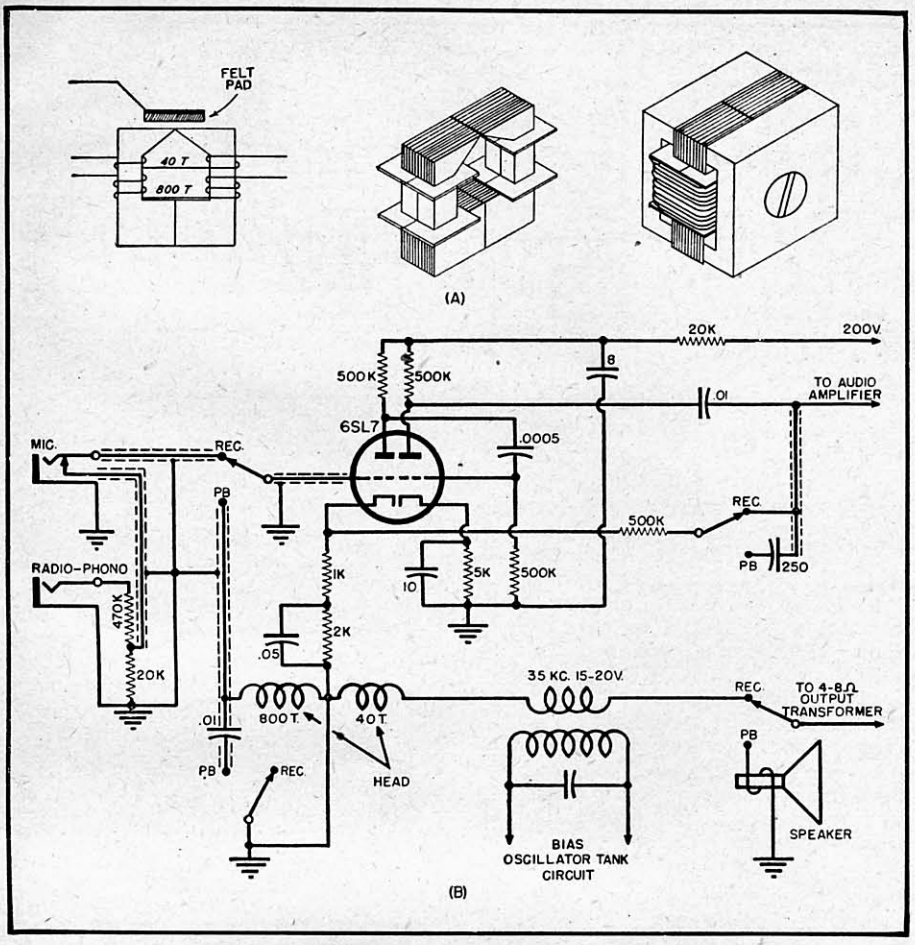


Fig. 4. (A) Construction details of head developed for use with "Hyflux" tape. (B) Basic record-reproduce circuit using high impedance head.

though it is desirable to have as narrow a gap width as possible, as far as high frequency resolution is concerned, it is at the same time desirable to have as wide a gap as possible from an energy relation standpoint. This is true because the output of the playback head is naturally dependent upon the total amount of magnetic flux which can be placed across the magnetic gap from the recording tape.

Electronic Circuits

The electronic circuits of a magnetic tape recorder may be divided into four parts for purposes of description and discussion: (1) the input matching transformer, (2) the equalizer circuit, (3) the audio amplifier, and (4) the high frequency bias oscillator.

Since most practical recording and playback head designs have relatively low impedance windings, it is necessary to use a matching transformer between the head and the input of the amplifier. As the signal at this point is of rather low level, precautions must be taken to shield the transformer both electrically and magnetically. The only other real requisite for the transformer is that it have a reasonably good frequency response.

It is well-known to those versed in the art of magnetic recording that equalizing networks are necessary to compensate for the constant current recording characteristic of the particular head and recording medium used. Because of the nature of magnetic recording, the constant current frequency response characteristic rises approximately 6 db. per octave of recording medium used. Either single or multiple stage equalizers may be used; however, practice shows that single stage circuits can give very satisfactory results.

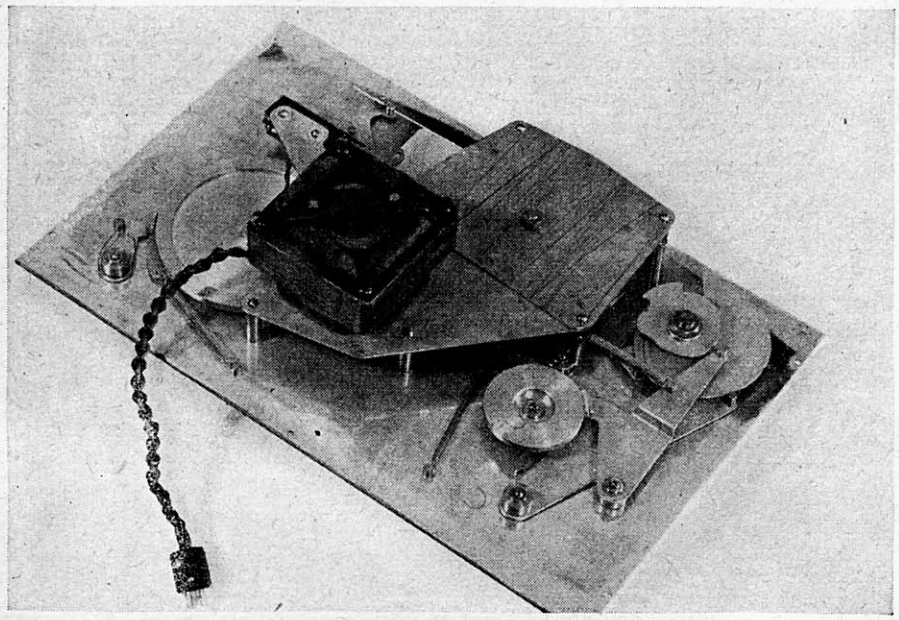
For the playback operation, the amplifier circuit will be considered in two parts. The driver and output stages, as one part, can be considered the equivalent of the average audio amplifier of a radio receiver in design and characteristics. The other part is a pre-amplifier, which is necessary to compensate for the losses in the equalizer and for the difference in signal level at the secondary of the input matching transformer and that at the output of the detector stage of a radio. This makes possible the design of an attachment which contains only the pre-amplifier and equalizer circuits. The signal from this arrangement may be fed into the audio amplifier of a radio in the same manner as for phonographs.

In an attachment as described in the preceding paragraph, it is necessary to have a low power output stage for the recording function. This allows normal radio listening while recording.

The present method of recording on magnetic tape requires a source of high frequency used in conjunction with the audio signal. A simple, noncritical Hartley oscillator circuit serves this purpose excellently. The bias signal is applied to a separate winding on the recording head. The only critical requirement with this circuit is that it be sufficiently well shielded to prevent heterodyning with an associated radio.

As in any relatively high gain audio amplifier, it is necessary to take adequate precaution with the power supply filter and with the layout of components, particularly in the preamplifier stages, to reduce the hum level to a minimum.

Perspective view of under side of driving mechanism.



Driving Mechanism

Fig. 1 is a block diagram of the electronic components of a complete

(*Continued on page* 131)

non-inductive, Discohm, line voltage reducers, and fluorescent lamp resistors.

The company's complete line of radio amateur relays for standard applications are also listed in the catalogue. Included among stock items are antenna, r.f. break-in, bandswitching, keying, overload, time delay, safety, sensitive, latch-in, and remote control relays and transmitter control panels for low, medium or high power ham rigs, in kit form or completely assembled and wired.

A copy of catalogue D-30 may be procured by writing to the Radio and Electronic Distributor Division, *Ward Leonard Electric Company,* 53 W. Jackson Boulevard, Chicago 4, Illinois.

SERVICE TEST EQUIPMENT

The *Specialty Division* of *General Electric Company's Electronics Department* has just published a new 18-page catalogue covering service test equipment.

The publication lists the specifications of nine instruments in the division's line of test equipment; tube checker, Type YTW-1; signal generator, Type YGS-3; oscilloscopes, Types CRO-3A and CRO-5A; capacitance-resistance bridge, Type YCW-1; unimeters, Types YMW-1A and UM-3; sine or square-wave generator, Type YGA-2; and high voltage multiplier, Type YYW-1.

A copy of this catalogue, which has been designated ESD-129, may be secured from company distributors or direct from the *Specialty Division, General Electric Company,* Electronics Park, Syracuse, New York.

-30-

Recording of Sound

(*Continued from page* 58)

self-contained unit with the main switching functions given to illustrate how the components of the circuit are utilized for either recording or reproducing.

The amplifier consists of two voltage stages utilizing a single 6SL7, an equalizer network, a 6SC7 as a phase inverter, and two 6V6's in push-pull in the output stage. Other components shown are record-playback head with a non-inductive resistor in series, a Hartley oscillator for the bias supply, a neon lamp volume indicator circuit, and a well-shielded input transformer.

With the selector switch in the "record" position, a signal may be fed from a microphone into the first stage, or from the detector stage of a radio, or from a phonograph into the second stage. From that point the signal may be followed through the equalizer network, the remaining stages of the amplifier, and thence to a portion of the winding on the record-playback head through a non-inductive resistor. A signal of 35-60 kc. from the bias oscillator is fed to the other portion of the winding on the head. The method of applying the high frequency bias sig-

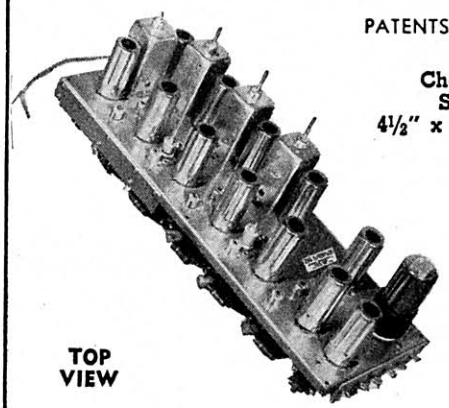
MANUFACTURERS' SERVICEMEN

This Sensational Picture IF & Sound IF Strip developed by our engineering staff and enables you to build a 10"-12" 15" - 20" Direct View or Projection Type Receiver with FM Sound Supplied with a 13 Channel RF Front End Unit

PICTURE IF & SOUND IF STRIP

PATENTS PENDING

Chassis Size 4½" x 13" x 5"



TOP VIEW



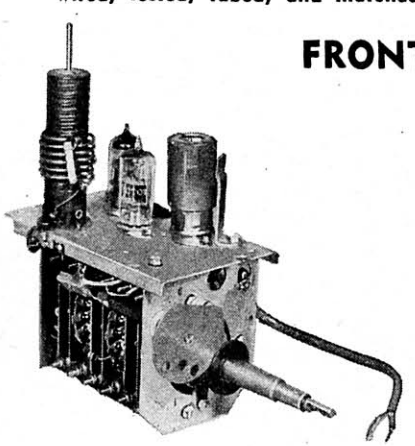
BOTTOM VIEW

1. PICTURE IF STAGES
   Five picture IF stages of amplification and second detector
2. SOUND IF STAGES
   Two IF stages with limiter and discriminator
3. VIDEO STAGES
   Two stages of Video with a frequency response of 4.5 mc/s
4. ONE D.C. RESTORER
5. IF FREQUENCY
   Audio 21.25—Picture 25.75
6. TUBES
   5—6J6—Picture IF Amplifier
   1—6J6—Picture IF Amplifier & Detector
   1—6AU6—1st Video Amplifier
   1—6K6gt—2nd Video Amplifier
   1—6AU6—Limiter
   1—6AL5—D.C. Restorer
   1—6AL5—Discriminator
   2—6BA6—Sound IF Amplifier

Picture IF Band Width 4.5 mc/s

• All the Above Circuits and tubes are contained on 1 chassis. • Front End Unit on separate chassis. • Both Picture IF & Sound IF delivered completely wired, tested, tubed, and matched ready for use.

FRONT END



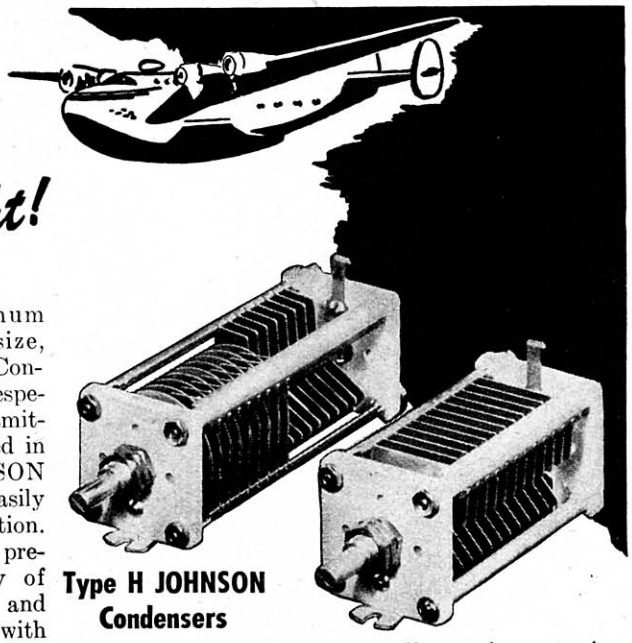
The Front End covers channels from 44 to 88 mc/s and 174 to 216 mc/s (13 channels). Matched antenna input for 300 ohm line.
Tubes: 1-6J6 RF Amplifier 1-6J6 Converter 1-6J6 Oscillator

PRICE $119.50 DEALERS NET

Contact Us for your Local Distributor

TELEVISION INDUSTRIES

540 BUSHWICK AVE.
BROOKLYN 6, N. Y.



Light in Weight!

Combining minimum weight with small size, JOHNSON Type H Condensers are designed especially for aircraft transmitters. Simple and rugged in construction, JOHNSON Type H Condensers easily withstand heavy vibration. STEATITE end plates prevent any possibility of "short circuit loops" and permit panel mounting with both rotor and stator insulated from ground. Capacities and spacings are provided for low and medium power stages. Aluminum plates are .020" thick. End plates are 1½" square.

Type H JOHNSON Condensers

Excellent for police equipment, airline ground equipment, amateur equipment, test equipment, VHF and others.

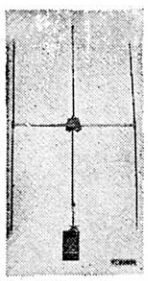
They're small in size—great in performance!

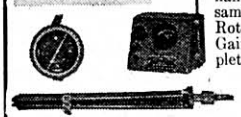
For Further Details Write for Latest JOHNSON Catalog

JOHNSON *a famous name in Radio*

E. F. JOHNSON CO., WASECA, MINNESOTA

RC-163 VERTICAL 3-ELEMENT ARRAY





With Electrically Operated Rotator Continuously Tunable 20 to 39 Mc. (10-11 & 15 Meters)

Operates under all outdoor conditions. Assembly consists of 3-element array, rotating mechanism, field strength meter, Surveyor's Compass and Tripod, and all accessories and cables.

- All Three Elements Driven
- Feeds with 72-ohm line
- Rotator strong enough to handle additional beams at same time
- Continuously Rotatable
- 4 to 5 db Forward Gain; Cardioid Pattern, completely null at back
- Simplified Assembly, easy tuning, ready to go on air one-half hour after uncrating!
- Changeover from 10-11 to 15 meters or back, in ten minutes

Operates on 12V 4½ Amps DC. Shpg. wt. 330 lbs. Your net cost, complete assembly, FOB Lynbrook, N. Y. **89.50**

HOTTEST ITEM OUT!! Make your SCR-522 Receiver operate on 144 to 148 Mc. with ONE DIAL control, in less than 1 hour! Parts and instructions..... Include 8¢ Postage 3.00

ARC/5 2-3 Mc XMTR	$9.00
BC-454 3-6 Mc RCVR	5.50
BC-455 6-9 Mc RCVR	5.50

XMTG TUBE BARGAINS!

807	$1.00	8025A 500 Mc Triode	$3.95
805	3.95	35TG	2.95
810	5.95	100TH	7.50
		250TH	11.95

ALL TUBES SHIPPED EXPRESS.

MERIT RADIO SUPPLY CO.

471 Merrick Road LYNBROOK, N. Y.

TECHNICAL KOs

Power Xformer 850VCT, 750VCT @ 200 Ma, 5V @ 3A, 6.3V @ 5A $4.14

6V6 Metal	$0.89	6L6 Metal	$0.95
12SQ7 Metal	.32	12K8 Metal	.32

.01-150V Paper (Midget)	60 for 1.00
.02-1600V Paper	10 for 1.00
.1-600V Paper	12 for 1.00
Mica—.002, .005, .006 etc. 600V	.08
Cond. Kit .01-.00001	100 for 3.00
Bathtub Kit 3x.1, .5, .1 etc.	10 for .89
Resistor Kit ½ & 1w Assorted	100 for 1.49
Choke—Nationally Known 12H-80 Ma-250 ohms	1.09
Choke—Nationally Adv. 10H-100Ma-250 ohms	1.09

OIL-FILLED NATIONALLY ADV.			TRANSMITTING MICAS		
.05 MFD	1000V	$0.28	.000025	2500V	$0.11
.1	2500V	.60	.00005	1600V	.12
.1	7500V	1.85	.00005	2500V	.14
2X.1	7000V	4.75	.00005	5000V	.95
.12	15000V	5.95	.000067	2500V	.20
.25	1000V	.35	.00007	2500V	.14
.25	4000V	2.75	.00025	2500V	.25
.25	6000V	4.00	.00025	5000V	.95
10X.25	600V	1.00	.0004	2500V	.18
.5	600V	.28	.0005	2500V	.18
.5	1000V	.35	.00072	5000V	.95
.5	2000V	.40	.0008	5000V	.95
.5	3000V	.60	.001	2500V	.18
.75	2000V	.55	.0015	5000V	.95
.77	330VAC	.35	.002	2500V	.27
1.0	1000V	.45	.002	3000V	.66
2.0	1000V	.60	.0025	1200V	.15
4.0	600V	.60	.00275	2000V	.28
4.0	1000V	1.00	.003	2500V	.30
6.0	1000V	1.25	.004	2500V	.36
6.0	2000V	1.75	.005	3000V	.66
8.0	600V	.70	.006	2000V	.33
8.0	1000V	1.75	.008	1200V	.12
10.0	600V	.85	.01	1200V	.14
30.0	330VAC	2.35	.02	600V	.11

$2.00 min. order F.O.B., N.Y.C. Add postage. 50% deposit, balance C.O.D. with all orders. Manufacturers' inquiries invited.

TECHNICAL RADIO PARTS CO.

265 Greenwich St. Dept. N-8 N. Y. 7, N. Y.

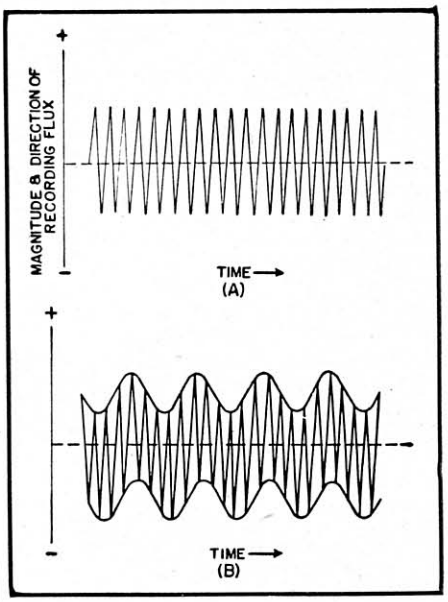


Fig. 5. Typical oscillograph patterns. (A) Bias supply and (B) with superimposed audio. It is essential that the wave shape of the bias supply be as nearly perfect as possible. Any non-uniformity will result in noise and distortion on a recorded signal.

nal and the audio signal to separate or tapped windings has been found to be more satisfactory than mixing in the amplifier.

The non-inductive resistor serves two purposes; to match the audio winding of the head (approximately 1 ohm) to a four or eight ohm winding of the output transformer, whichever may be chosen, and to increase the ratio of the signal to the inherent noise of the amplifier (i.e., hum and thermal noise present when gain control is turned down).

The method of recording used requires a magnetically saturated medium to which a high frequency bias signal is applied with the audio signal superimposed. For the type core used in the head design described from ten to fifteen ampere turns are required for the bias component, and from two to four ampere turns for the audio component of the signal.

For the playback function, the selector switch is set accordingly and the signal from the head passes through the input transformer into the first stage of the amplifier. The signal passes through the amplifier in the same manner as for recording, and then to a speaker.

Care must be taken in positioning and shielding the input transformer. Experience has shown that it is most practical to have it as near the head as possible. Shielding should be both electromagnetic and electrostatic. The voltage gain of the transformer should be from 75 to 100.

The recording volume level indicator consists of a small neon lamp biased so that the maximum desirable peak signal at the plate of one of the output tubes will cause the lamp to ignite. A potentiometer arrangement for supplying the bias voltage to the lamp facilitates proper adjustment.

NUMBERS 4 and 5 OF THE

WALSCO *Hit Parade*

THE SENSATIONAL, NEW, SCIENTIFIC

WALSCO STANDARD TEST RECORD

FOR IMMEDIATE . . ACCURATE . . AUDIBLE ADJUSTMENT OF RECORD CHANGERS AND COIN OPERATED PHONOGRAPHS . . . . . SOLVES THE PROBLEM OF ADJUSTING PICKUP AND TRIPPING MECHANISM THROUGH SOUND



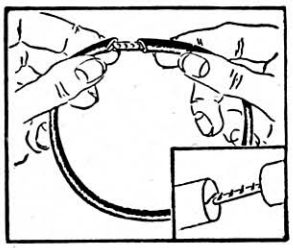
- Three Tone lead-in grooves permits immediate adjustment to proper set down position of the pick-up through audible means.
- Made to RMA and NAB standards.
- Record plays in less than 40 seconds.
- Audio tone at end of record indicates proper adjustment of tripping action.

The WALSCO Standard Test Record saves time and increases efficiency in the adjustment of record changers and coin operated phonographs. *Write for full information.*

WALSCO UNIBELT

THE UNIVERSAL DIAL DRIVE BELT CAN BE CUT TO FIT ANY DIAL DRIVE

Will not Slip or Stretch



"UNIBELT" comes in 5-foot length spools and can be installed without taking dial mechanism apart. A real time and money saver. Eliminates the need for stocking numerous sizes of belts.

Free sample and literature. Write to Dept. A

WALSCO *products*

Help The Radio Man

WALTER L. SCHOTT CO. BEVERLY HILLS CALIF. CHICAGO 5, ILL.

AMAZING BLACK LIGHT

Complete with resistance line cord & ultra violet ray filter. Ready to operate from your 110v. AC line. Rigid Mount.... $2.95
Gooseneck Mount $3.49
Replacement Bulbs—$.35 ea.

FILTER CHOKES

30 Henry 50 MA. 2500 volt RMS 500 ohm DC resistance. Open frame..... $.75
10 Henry 100 MA. 455 ohm DC resistance. Mfd. by Westinghouse, hermetically sealed ..... $.85

WIRE WOUND RHEOSTATS

50 Watts, 8 ohm, 35 ohm and 250 ohm..... .85
25 Watts, 100 ohm, 25 ohm, 35 ohm, 2500 ohm .75

CAPACITORS

1100 MFD. 50 Volt ..... .90
1500 MFD. 50 Volt 1.10
2000 MFD. 50 Volt 1.25
500 MFD. 200 v. 1.75

SWITCHES

Slide switch: Stackpole DPDT ..... .15
SPDT momentary, center off position, long bat handle ..... .29
4 pole DT 10A. 125 v. ..... .50
SPDT center off position, 6A. 125V. ..... .29

CONDENSERS

3 Gang Variable Condenser 50 MMFD per section Ceramic insulation ..... .65
4 Gang Variable Condenser 50 MMFD per section Ceramic insulation ..... .85
Oil filled condensers: .03 mfd. 7500 v. DC..... 1.15
.30 mfd. 2000 v. DC..... .65
1 mfd. 2500 v. DC..... 1.25
1 mfd. 1200 v. DC..... .65
4 mfd. 2000 v. DC..... 2.75
Variable Condenser 2.5 to 10 mmf..... .45
10 Mfd 1500 v. DC 3.15

BARGAIN SPECIALS!

SURPLUS SPECIAL—Small 110 v. AC open frame motors, 1/8" shaft, 2700 R.P.M., 1/70 H.P., mfd. by BARBER COLMAN CO. ..... $2.00 ea.

MISCELLANEOUS

PL259A Coax Connector and Socket. *Silver Plated for RG8U and RG11U..... $0.50 pr.
3AG fuse holder. Mfd. by Littelfuse..... .20
Flexible shafts, 4½ inches long.....3 for .25
Grounding straps, heavy flexible wire, lugs both ends—4 inches long .....4 for .05
Mica trimmers: Variable 3-30 Mmfd 4 gang .. .20
Variable ceramicon 4-30 mmf. 7-45 mmf. .... .25
Filament Transformer: 5 volts @ 4 amp. 110 volt pri. open frame, porcelain standoffs. Mfd. by G.E. 1.00
0 to 15 DC Milliammeter. Simpson 3½" Bakelite case 2.95
Pilot Light Assy. 1" Ruby jewel complete with 110 v. AC Candelabra base bulb..... .40
12 v. Edwards' Buzzer complete with push button ..... .40

SYNCHRONOUS MOTOR

1/8" shaft 110 v. AC 60 cy, 1 RPM, 2.2 watts Mfg. by Hayden Mfg. Co. $1.25

No sale less than $2.00. All prices FOB NewYork City. Add 25c to cover postage. 20% Deposit required with all orders.

A. M. RADIO SALES COMPANY 345 CANAL ST. NEW YORK CITY 13, N. Y.



Deluxe Table Model. Can be screwed down or hooked to table with C Clamp. Complete $31.75

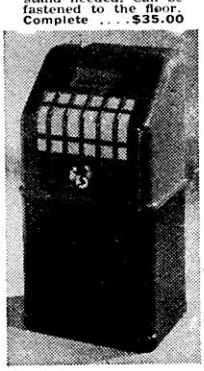
COIN RADIO KITS SEPARATELY OR COMPLETE UNITS

PLASTIC CABINET AND GRILL for table model ..... $ 5.75
Richly grained brown or ivory marble effect. No stains—no burns—No refinishing. Exceptional acoustics only equaled by this type of cabinet.
TIMERS (Quarter 1 and 2 hour or 5c 10 Minutes 4.95
AC RADIO Chassis RCA 5-Tube Super-Het, Completely Wired 15.35
METAL HINGED BASE AND BACK with No-Cheat Coin Box and Brackets..... 3.45

MISCELLANEOUS ACCESSORIES

2 LOCKS, WING NUTS, NAME PLATES, Etc. $1.80
CONSOLE PLASTICS BASE to complete Console Model 4.25
BEAUTY PARLOR DRYER HEAD SETS AND HOLDER..... 1.80

Deluxe Console, no stand needed. Can be fastened to the floor. Complete $35.00



RADIO-COIN-MATIC BOX 9465 1110 S. NORMANDIE LOS ANGELES 6, CALIF.

Fig. 2 is a block diagram of the circuit components for a radio adapter unit. Much of the circuit is the same as for the self-contained unit with the exception of the final amplifier stages. It is desirable to have the recording amplifier self-contained in the adapter and to use the radio amplifier for playback only. Two circuits are required between the unit and the radio, one for recording radio programs and the other for the reproduction of recordings. The signal from the equalizer, approximately 0.5 volt, is fed into the phonograph jack or the first audio stage. Other than this the operation of this unit is the same as that of the self-contained unit.

Record—Reproduce Heads

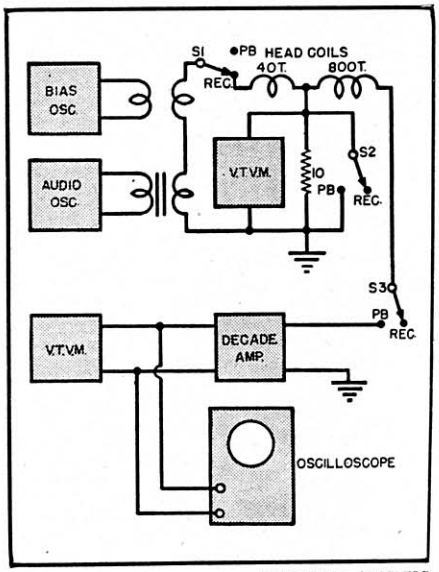
Fig. 3 is a schematic drawing of the construction of an experimental record-playback head of low-impedance type. The core is built up in two legs of .007 inch *mumetal* laminations. Each leg is wound with 80 turns of 28 heavy *Formvar* copper wire, one leg having a tap at the first 30 turns. The tap is grounded, and for recording the audio signal is fed to the 30-turn winding and the bias signal to the 130-turn winding. During playback the signal from the 130-turn winding is fed to the primary of the input transformer. The ground surfaces of the two legs of the core are butted together with a .0005" thick non-magnetic spacer at the recording gap and tacked at several points with solder. The head may be potted in a small magnetic shield can.

Although the coils are wound on the core in a hum-bucking arrangement, it may be necessary to have additional magnetic shielding between the head and the driving motor and/or the power transformer.

High-Impedance Head

The new head developed by *The Indiana Steel Products Company* incorporates many improvements which add to the flexibility and fidelity of

Fig. 6. Circuit diagram shows test setup for checking wave shape of bias oscillator.



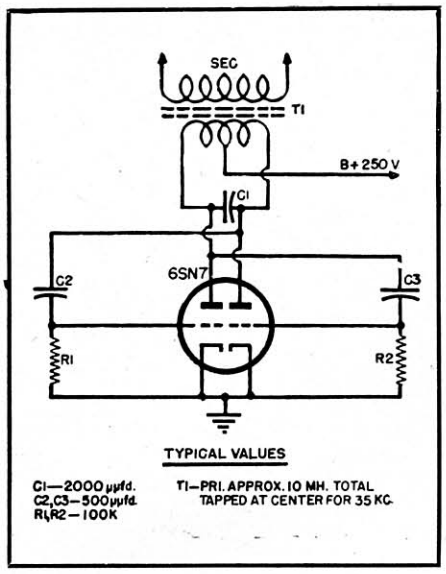


Fig. 7. Diagram of push-pull bias oscillator.

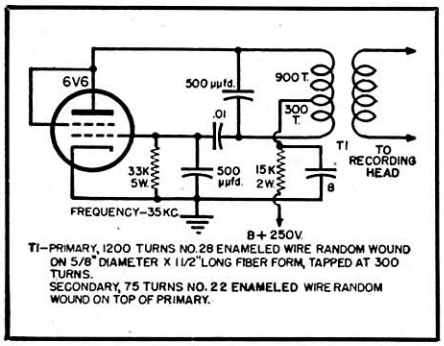
magnetic requirements. This new design incorporates a flat top so that a pressure pad can be used to assure more intimate contact of tape with the gap area. This head was designed in conjunction with *Hyflux* tape and is illustrated in Fig. 4A.

Tests have indicated that *Mumetal* is a satisfactory material for a dual purpose head. Indications are that *Permalloy* or other materials of similar composition and characteristics are also satisfactory. It should be emphasized, however, that all magnetic materials of this nature must be properly heat treated after stamping or other cold working. It is imperative that close tolerances shown for pole dimensions be closely held. The gap length should be as short as possible consistent with uniformity. The best possible mechanical joint will result in an effective magnetic gap of approximately .0005". Spacers of any thickness under .001" usually contribute to non-uniformity and it has been found more desirable to use a plain butt joint between the two polished surfaces when a very small gap is required. A basic record-reproduce circuit for use with this head is shown in Fig. 4B.

Bias and Audio Current Requirements

Both bias and audio flux above the

Fig. 8. Bias oscillator circuit as applied to magnetic tape recording.



Here it is GIANT War Surplus CLEARANCE!

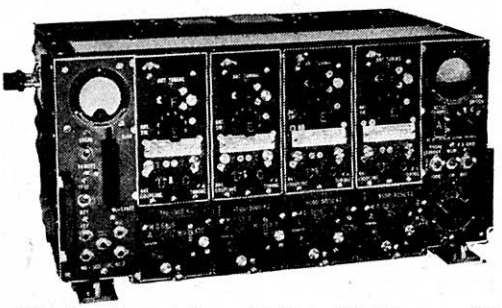
MODEL ATD
AIRCRAFT TRANSMITTER

Covers 540 Kc. to 9050 Kc. C.W. or fone, designed for Dynamotor Operation. Power supply requirements are 380 volts and 1000 volts DC.

Separate Ant. Tuning units covering the following frequencies

540—1500 Kc.
1500—3000 Kc.
3000—9050 Kc.

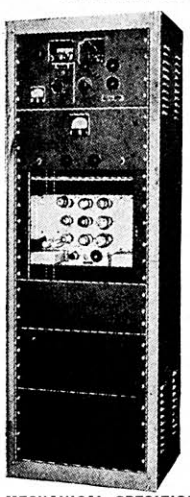
10½" high, 12¼" deep, 21½" long. Shipping weight 100 lbs. Price F.O.B. New York City.



Tube line-up as follows: RF Osc. 6L6—RF Amp. 814 Audio—6SL7 Pre Amp. into 6L6 driver and side tone amplifier with pair of 6L6 modulators, screen of oscillator tube, regulated with VR 150 Tube. All circuits are metered.

FOR FAST TURNOVER

MASTER OSCILLATOR MI-19427-B



This unit was built for R.C.A. Add a final—becomes a complete transmitter with signal shifter. Voltage regulated power supply is perfect for Television sweep circuits for field or station use or wherever 300 v. must be maintained under varying load conditions—COMPLETE (less tubes) $225.00

Limited quantity
COMPLETE ONLY $49.50

TECHNICAL SUMMARY

ELECTRICAL CHARACTERISTICS
Output Frequency . . 2 to 20 megacycles
Output Level, Buffer Amplifier . . . . . Sufficient to drive an RCA-807
Modulation Frequency . . 650 cycles ± 150 cycles
Frequency Deviation (maximum) . . . . . ± 500 cycles
Power Consumption . . . . . 200 watts
Power Supply . . 115 230 volts, 50/60 cycles
Oscillator Filament Current . . . . . 0.05 ampere d-c
Amplifier and Tone Generator Filament Voltage . . . . . 6.3 volts a-c

TYPICAL PERFORMANCE DATA
Frequency Change
Line voltage change, ± 10 per cent . . . . . 0.0005 per cent
Temperature change, per degree Fahrenheit . . . . . 0.0007 per cent
Relative humidity change of 1 per cent over the range of 30 to 95 at a dry bulb temperature of 110 degrees F. . . . . 0.0003 per cent
Drift from cold start, first reading taken within 1 minute after applying power: Frequency deviation at the end of the first hour . . . . . a negative drift of 100-400 cycles (measured at 7 mc)

TUBE COMPLEMENT
Electron-Coupled Oscillator 2 RCA-3Q5-GT
Buffer-Amplifier 1 RCA-807
Tone Generator . . 1 RCA-6AB7, 1 RCA-6F6
Regulated Power Supply: 2 RCA-5U4-G, 5 RCA-6Y6-G 1 RCA-1852, 2 RCA-VR-150 30

COMPLETE (Less Tubes) SPECIAL $225.00

MECHANICAL SPECIFICATIONS—Dimensions: Height, 66 9/16 in.; Width, 22 in.; Depth, 17⅛ in. Weight, 275 pounds.

WRITE FOR LATEST BULLETIN 2N8

20% deposit with all orders unless Rated—All prices F.O.B. N. Y. City

NIAGARA RADIO SUPPLY CORP.
160 GREENWICH ST., NEW YORK 6, N. Y.

EE-8 B
ARMY SIGNAL CORPS FIELD TELEPHONES

Portable field unit, fully equipped with ringer, coils, condenser, generator and crank, can be used anywhere. Various Manufactures. Regular $28.50 value. OUR PRICE (without carrying case) with handset $10.50 each. UNUSED. IMMEDIATE DELIVERY.

Maspeth Telephone & Radio Corporation
427 Flatbush Ave. Extension
Brooklyn 1, N. Y.
Telephone ULster 7-0500



RADIO COURSES

Preparatory, Broadcast, Marine Operating, Servicing, Aeronautical, Television, Frequency Modulation, Radar.

Classes forming for mid-year term February 2nd. Entrance Exam. Jan. 12th.

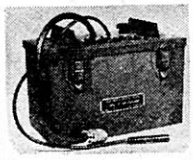
Veteran Training. Literature.

COMMERCIAL RADIO INSTITUTE
38 W. Biddle St. (Founded 1920) Baltimore 1, Md.

SAVE $ ON RADIO SURPLUS

***ATTENTION:* Prospectors, Explorers for Hidden Treasures!**

Do you seek hidden treasures or rare metallic ores? If so, construct a U.S. Army Type of Metallic Mine Detector from these U.S. Army Mine Detector Amplifiers that we are offering at a ridiculously low price. Complete Amplifier (as illustrated) (less tubes and batteries) with Battery case and cables. Cables, headphone cord and jack (no phones). Complete Army wiring diagram. U.S. Army DETECTOR SET Amplifier Type AN/PRS-1, as described..Only **$2.49**



No. C.O.D.'s. Eveready 45 volt batteries #482. **$1.65** ea., 6 volt A. **73c.** 2—1N5 tubes, **95c** ea.

U.S. SIGNAL CORPS 5 METER SHORT WAVE XMTRS.

(72.2Mc) XMTRS and TUBE only, less mike, batteries and antenna. One 1½ volt dry cell and 67½ volts of B operates it. Just attach di-pole, key or mike, connect the batteries and it's ready to use. Signal Corps spec. wired with silvered wire, mica condensers, and precision resistors. Highly stable circuit with Lo-Loss silvered inductance. (Adjustable padder) Schematic supplied. Converts easily to walkie-talkie and Ham bands. Only..... **$2.95**

No C.O.D.'s.

SELENIUM RECTIFIERS

Lots of 12.....**65c** Single Lots **75c**

BRAND NEW SENSITIVE RELAYS MICRO-AMMETERS MODEL 705

(2½-0-2½ 2 0-2 range) with A.C. Rectifier. Cost Uncle Sam $45.00. Our price **$10.00**



GENUINE SIGNAL CORPS FEATHERWEIGHT HEADPHONES WITH CORD AND PLUG 2000 OHMS—8000 OHMS IMPEDANCE **$1.00**

NATIONALLY ADVERTISED OIL FILLED FILTER CONDENSERS

1.—MFD—1000 working volts. 4 for.....**$1.00**

WEBSTER RECORD CUTTING HEAD

Here is your opportunity to buy a genuine **WEBSTER HOME RECORDING CUTTING HEAD.** These units are all Brand new and were made for a nationally advertised manufacturer to be in their quality Home Recording Radios. Size 1⅜x2⅞ ready to fit your cutting arm or bracket. **SPECIAL**.....**$2.95**

3 BAND ALL-WAVE DIAL 6" DIAMETER.....**75c**

GENERAL ELECTRIC 5 AMPERE 110-125 VOLT, 60 CYCLE WATT HOUR METERS, SLIGHTLY USED, PERFECT CONDITION, SAME AS USED IN YOUR HOME..... **$3.50**

AMPLIFIER CHASSIS, SIZE 18"x8"x2½". BLUE CRACKLE FINISH DRILLED FOR CONDENSERS—TRANSFORMER AND SOCKETS.....**65c**

STROMBERG-CARLSON, 3 BAND ALL-WAVE TUNING UNIT, COMPLETE WITH TRIMMERS, BY-PASSES AND BAND SWITCH, READY TO INSTALL—DIAGRAM, etc. **$3.75**

8—9 GANG PUSH BUTTON TUNING UNIT (PLEASE SPECIFY). COMPLETE WITH BUTTONS.....**25c**

24 VOLT D.C. AIRCRAFT MOTOR, APPROX. ⅛ H.P. ALMOST NEW **$1.50**

U.S. AIR FORCE RESISTOR AND CONDENSER ASST. ¼-½-1 WATT—100 PIECES.....**95c**

U.S. AIR FORCE MICA CONDENSER ASST. 100 PIECES **$1.25**

LOW-LOSS-SHORT WAVE Variable Condensers AT RIDICULOUS LOW PRICE ¼" Shaft Type

3 Plate—12-15 MMFD.	15c
5 Plate—20 MMFD.	20c
9 Plate—36-40 MMFD.	25c
10 Plate—40 MMFD.	25c
11 Plate—45-50 MMFD.	26c
14 Plate—55-60 MMFD.	27c
27 Plate—100-110 MMFD.	45c
37 Plate—150 MMFD.	50c
38 Plate—150-155 MMFD.	55c
53 Plate—210-21 MMFD.	60c

Lock Type Air Trimmer Variable Condensers

3 Plate—12-15 MMFD.	10c
5 Plate—20 MMFD.	11c
7 Plate—28-30 MMFD.	13c
8 Plate—30-35 MMFD.	13c
10 Plate—40 MMFD.	14c
13 Plate—50 MMFD.	17c
14 Plate—56 MMFD.	20c
20 Plate—80-100 MMFD.	25c
27 Plate—100-110 MMFD.	35c

OIL FILLED By-Pass Filter Condensers (Bathtub Type)

Removed from Gov't apparatus, but Electrically Perfect IC-1—Dual (2)—.1-600 VOLT IC-2—.5-MFD—600 VOLT EVERY ONE GUARANTEED.....Each **15c**

NEWARK SURPLUS MATERIALS CO.

324 Plane Street Dept. N. Newark 1, N. J.

PRACTICAL TECHNICAL TRAINING FOR YOU

Specialize in **Electronics, Radio, Electricity, Refrigeration, Heating and Air Conditioning, or Welding. Prepare in one year for position as Technician, or in two additional years secure your B.S. Degree in Electrical Engineering with major in Machinery or Electronics.**

Write for booklet "Career Building"

MILWAUKEE SCHOOL of ENGINEERING

"A Technical Institute"

RN-2-48, N. Broadway and E. State, Milwaukee, Wis.

gap must be greater than that required by magnetic recording media of lower coercive force. The exact value of current required to produce the proper flux depends on size of the head structure, number of turns in the coil, and pole and gap dimensions. For a head constructed in accordance with Fig. 4A the following bias and audio currents are typical of those giving optimum results on *Hyflux* coatings:

Bias frequency	**35 to 60 kc.**
Bias current	**60 to 75 ma.**
Audio	**20 to 35 ma.**

The bias current is chosen to give highest mid-range output with satisfactory low frequency waveform. Low bias results in low frequency distortion, generally low output, and extended high frequency response. Excessive bias shows up in reduced high frequency response. A practical value should be selected which results in satisfactory freedom from low frequency distortion. A good rule of thumb is to select the bias frequency as five times the top audio frequency desired plus 10 kc.

It is essential that the wave shape of the bias supply be as nearly perfect as possible. Any non-uniformity in the positive and negative half cycles will result in noise and distortion on a recorded signal. It should be remembered that the recording of a signal is due to the displacement of the positive and negative bias peaks by the audio signal component. For example, during a positive half cycle of the audio signal, the bias may alternate through several cycles but each bias cycle will be displaced in a positive sense by the audio signal component. The direction and magnitude of the *remanence* on the tape is proportional to the mean value of the displaced bias cycles which is the audio signal

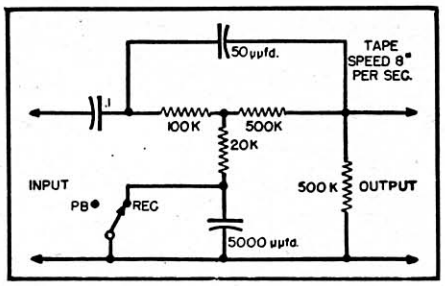


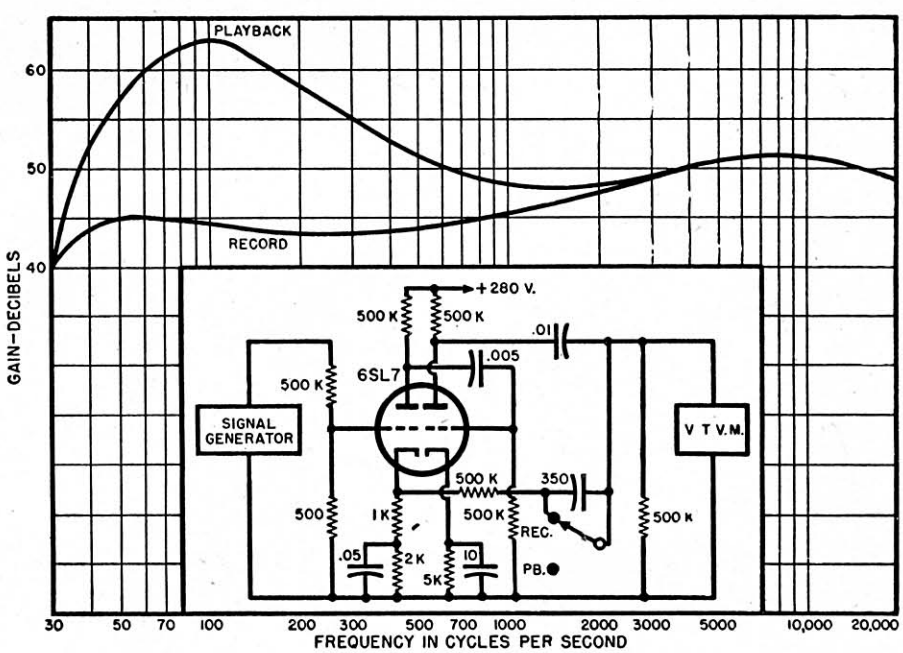
Fig. 9. Equalizer circuit for magnetic tape recording.

recorded. Since a new portion of tape is constantly being exposed to the gap influence, it is essential that several bias cycles take place for each half wave of audio frequency being recorded. This is necessary in order that any particular portion on the tape will have its hysteresis loops stabilized before leaving the gap area, thereby assuring that the magnetic remanence is linear and at the highest possible value. A typical oscillograph pattern of the sum of the bias and audio currents is shown in Fig. 5. The oscilloscope in this case replaces the vacuum tube voltmeter connected across the 10 ohm resistor shown in Fig. 6. Bias oscillator circuits which have been found to be satisfactory are shown in Figs. 7 and 8. The push-pull arrangement of Fig. 7 is highly recommended because it provides an output of better wave shape.

Noise

There are two types of noise which must be considered in magnetic recording. While these two kinds of noise are related and result from the same cause, namely, magnetic variation, the type which rides on the signal known as "modulated noise," is the most perplexing. Naturally this type of noise is nearly absent when no sig-

Fig. 10. Response curves show the low frequency boost available from the circuit shown. Inverse feedback is used to obtain these results.



SELENIUM RECTIFIERS

FOR ALL APPLICATIONS

FULL WAVE BRIDGE TYPES

Input	Output	Current	Price
From 0-18 V.A.C.	From 0-14 V.D.C.	1 AMP.	$2.49
0-18 V.A.C.	0-14 V.D.C.	3 AMP.	3.49
0-18 V.A.C.	0-14 V.D.C.	5 AMP.	4.95
0-18 V.A.C.	0-14 V.D.C.	10 AMP.	7.95
0-18 V.A.C.	0-14 V.D.C.	15 AMP.	10.95
0-18 V.A.C.	0-14 V.D.C.	20 AMP.	13.95
0-18 V.A.C.	0-14 V.D.C.	25 AMP.	16.95
0-18 V.A.C.	0-14 V.D.C.	30 AMP.	19.95

HALF WAVE TYPES*

Input	Output	Current	Price
From 0-18 V.A.C.	From 0-7 V.D.C.	3 AMP.	$2.25
0-18 V.A.C.	0-7 V.D.C.	5 AMP.	2.95
0-18 V.A.C.	0-7 V.D.C.	10 AMP.	4.95
0-18 V.A.C.	0-7 V.D.C.	15 AMP.	6.95
0-18 V.A.C.	0-7 V.D.C.	20 AMP.	8.95
0-18 V.A.C.	0-7 V.D.C.	25 AMP.	10.95

Input	Output	Current	Price
From 0-36 V.A.C.	From 0-28 V.D.C.	2 AMP.	$4.95
0-36 V.A.C.	0-28 V.D.C.	3 AMP.	5.95
0-36 V.A.C.	0-28 V.D.C.	5 AMP.	7.95
0-36 V.A.C.	0-28 V.D.C.	10 AMP.	13.95
0-36 V.A.C.	0-28 V.D.C.	15 AMP.	19.95
0-36 V.A.C.	0-28 V.D.C.	20 AMP.	25.95
From 0-120 V.A.C.	From 0-100 V.D.C.	2 AMP.	14.95
0-120 V.A.C.	0-100 V.D.C.	5 AMP.	19.95

Input	Output	Current	Price
From 0-36 V.A.C.	From 0-14 V.D.C.	3 AMP.	$2.95
0-36 V.A.C.	0-14 V.D.C.	5 AMP.	4.95
0-36 V.A.C.	0-14 V.D.C.	10 AMP.	7.95
0-36 V.A.C.	0-14 V.D.C.	15 AMP.	10.95
0-36 V.A.C.	0-14 V.D.C.	20 AMP.	13.95
0-36 V.A.C.	0-14 V.D.C.	25 AMP.	16.95

*Use with capacitor to obtain any voltage up to twice rated output.

FULL WAVE CENTER TAP

Input	Output	Current	Price
400-0-400 V.A.C.	0-450 V.D.C.	600 Mils	$5.95
9-0-9 V.A.C.	0-7 V.D.C.	22 Amps.	9.95

CAPACITORS

1000 MFD., 15 V.D.C. $0.98
2000 MFD., 15 V.D.C. 1.89

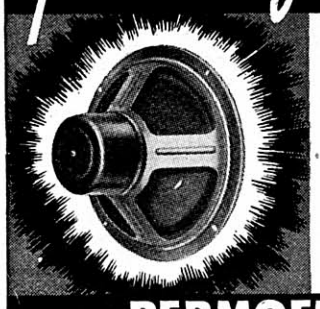
It would be impossible to give a complete listing of all our rectifier types. Our engineering staff is at your service to help you work out the application of selenium rectifiers to your specific problems. Write us for quotations or further information on capacitors and transformers to be used in conjunction with selenium rectifiers.

25% REQUIRED ON ALL C.O.D.'s—ADD 10% FOR PARCEL POST

OPAD GREEN COMPANY • 191 Greenwich St., Dept. 3

NEW YORK 7, N. Y. • Phone: BEEKMAN 3-7385

Permoflux SPEAKERS



YOUR JOBBER CAN SUPPLY YOU!

Permoflux quality and dependability—the same as supplied to the major set manufacturers—is your assurance of complete customer satisfaction. You'll find Permoflux Speakers easy to install and readily available in both PM and Electro-dynamic types. You'll find too, that it pays to give your customers "tops in tone" with a Permoflux Replacement Speaker.

TWO COMPLETE FACTORIES TO SERVE YOU — PERMOFLUX — WRITE FOR FREE BULLETIN

PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS

PERMOFLUX CORPORATION

4900 WEST GRAND AVE., CHICAGO 39, ILLINOIS

236 SOUTH VERDUGO ROAD, GLENDALE 5, CALIFORNIA

ALL at 59c each

RADIO TUBES—KNOWN BRANDS—BULK

43	1LN5	1H5	6F6	6Q7	25L6	6SA7	14B6
47	14A7	6A7	6V6	6X5	35L6	6SQ7	14Q7
OZ4	35Y4	6A8	6H6	7B7	50L6	50B5	117Z3

KITS

FM, CONDENSER & COIL, (88 to 108Mc), incl. Instructions ..... $ 4.95
5-TUBE SUPER-HET, complete with tubes and bakelite cabinet 12.50
6-TUBE SUPER-HET, complete with tubes and bakelite cabinet 13.95
INTER-COMMUNICATION, complete with cabinets and 3 tubes 12.75

3 WAY-PORTABLE RADIO (Leatherette 9"x6"x4½") AC-DC, comp. with batteries 19.90

PHONO MOTOR, complete with turntable 2.95
CRYSTAL PICK-UP ARM, including all hardware 1.75
OUTPUT TRANSFORMER (50L6) ..... .39
VOLUME CONTROLS, ½ or 1 Meg. with switches ..... .39
100-KNOBS ..... ASSORTED 4.95
100-SOCKETS ..... ASSORTED 4.95
100-CONDENSERS ..... ASSORTED ..... .001 to .02 ..... 3.95
100-RESISTORS ..... ASSORTED 1.50

BROOKS RADIO DISTRIBUTING CORP.

80 VESEY STREET (DEPT. B) NEW YORK 7, N.Y.

nal is present and is proportional in magnitude to the average signal. The maximum value of this noise is known as the "saturated modulation noise." The second type of disturbance, "unmodulated noise," may exist even when no signal is present and is usually due to either d.c. magnetization of the playback head or of the tape, or both. With proper adjustment of the equipment, this noise is usually very low, being down 60 to 80 db. from a maximum signal, particularly in the case of coated media. The magnetic variations responsible for noise are due, in many cases, to irregularities in tape coating and to poor resolution between recording medium and the gap. Noise of the above type is apparently due to small magnetic discontinuities and surface irregularities in the recording media which cause extraneous flux changes. In the case of modulation noise, a recorded signal is modulated by the flux changes.

Erasing Methods

The demonstration machines built by *The Indiana Steel Products Company* have all used permanent magnet erasing and are capable of good fidelity and satisfactory frequency response. The modulation noise seems to be more dependent on the recording medium than on erasing methods when the proper bias flux is used. It is possible to erase maximum signals on *Hyflux* with current at the bias frequency when sufficient power is used in a properly designed erase head. The ability of any erase head to completely erase signals is dependent not only on the coercive force of the medium, but also on the coating thickness. Since thin coatings produce satisfactory output, this tape is relatively easy to erase with the conventional high frequency erase head without excessive heating.

Recording Circuits

With high coercive force recording media, considerable high frequency energy in the form of gap flux is required. Every possible means should be used to improve head efficiency so that the required flux can be produced without heating due to eddy currents. An improved bias and audio series mixing circuit is shown schematically in Fig. 6. It has resulted in a considerably improved performance, less bias being required to produce a given value of gap flux. The high impedance pickup winding is open circuited during the recording operation, and a relatively high voltage at the bias frequency appears across its terminals. Care must be exercised in the construction of such a head in order that a breakdown of insulation will be avoided. A bias or audio supply of high voltage from open ended sources, such as the plate of a tube, is not recommended, since it is difficult to obtain efficient transfer to the head windings. Low voltage bias and audio circuits are easier to handle and require less shielding. In using the test setup shown in Fig. 6, both the

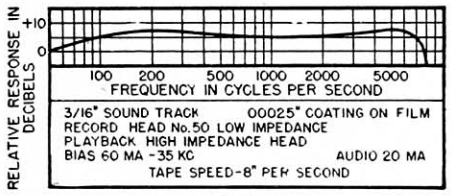


Fig. 11. Typical frequency response curve. Low and high frequency ends have been boosted to give flat frequency response.

bias and audio sources should be continuously variable in both output and frequency over the required range.

Equalization

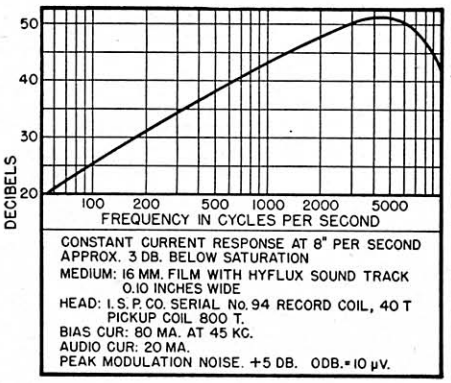
The subject of equalizing the normal tape response is frequently brought up by engineers and experimenters. Several arrangements which are practical can be used. Fig. 9 shows one version of a popular tone control circuit which is capable of satisfactory low frequency boost, in addition to considerable high frequency variation. The inverse feedback network included in the schematic (Fig. 10) performs satisfactorily. With a properly chosen high impedance pickup head winding, a very satisfactory high frequency boost can be obtained by resonating the circuit with a condenser of proper value shunted across the winding. If the top frequency response desired is 6000 c.p.s., the condenser is chosen to resonate the head at this frequency. As high as 20 db. boost at 6000 c.p.s. can be obtained in this manner.

In order to avoid low frequency overload distortion when the bias and audio currents are chosen for best high frequency performance it may not be desirable to use constant current over the audio range. This is done by pre-equalizing the highs to obtain a rising recording characteristic.

Frequency Response

With the proper choice of heads, circuits, correct bias and audio current adjustments, the frequency response of *Hyflux* tape at 7½" to 8" per second is easily equalized to from 100 to above 7000 c.p.s. flat to within 3 db. A typical frequency response curve employing a resonated head for high frequency boost and a bridged T net-

Fig. 12. Constant current response using Hyflux tape at 8 inches-per-second.



Lower Prices United Surplus Lower Prices

★ ★ ★ ★ ★

TRANSMITTER AND RECEIVER (SCR-528)

● **F.M. TRANSMITTER, BC-604C.** Temperature Crystal controlled. Freq. Range: 20 to 27.9 Mc. Uses 7—1619, 1—1624 tubes. Ten preset channels controlled by push buttons. All circuits Metered. Carbon and Dynamic Mic. Input. Size: 12" H., 9" D., 18" L. Output: 25 W. @ 100% Mod.

● **RECVR BC-603C.** Variable tuning; Freq. Range: 20-28 Mc. Uses: 1—6H6, 1—6J5, 1—6V6, 3—6AC7, 2—12SG7, 2—6SL7 tubes. Push buttons may be preset for ten channels. Calibrated dial. Built-in speaker. Squelch may be switched on or off. Size: 12" H., 7" W., 13" D.

This complete set requires small conversion for use in 28 Mc. Ham band. Shipped complete with tubes, 80 crystals, 2 dynamotors, Recvr and Xmitter schematic diagram.

All sets used but in good operating condition. 12 or 24 volts. (Kindly specify voltage desired.) Shipping wt. approx. 165 lbs. Nationally advertised brand. Specially priced at just..... **$59.50**

★ ★ ★ ★ ★

25 WATT HIGH GAIN AMPLIFIER

● A heavy duty P.A. System, modulator, etc. Uses: 2—6SJ7, 1—6N7, 2—6L6, 1—5U4 tubes. Two Mic. inputs and one phono input. Four controls are Mic. #1, Mic. #2, phono gain and tone control. Output impedance: 4, 8 or 15 ohms. Monitor jack on front panel. Housed in attractive black wrinkle finished cabinet 10½" High, 21½" Long, 15" Wide. Complete with tubes. Like new. Wt. approx. 60 lbs. **$44.50**

★ ★ ★ ★ ★

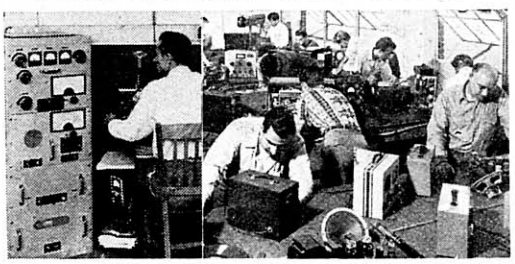
★ ★ ★ ★ *Just Off the Press* ★ ★ ★ ★

UNITED SURPLUS New 1948 free CATALOG! Chock-full of Spectacular Bargains. Write for your *free copy* today!

● QUANTITIES ARE LIMITED — ORDER NOW.
● All orders shipped f.o.b., Chicago.
● 25% deposit—Balance C.O.D.

United Surplus Materials
3313-19 W. OGDEN AVE.
CHICAGO 23, ILL.

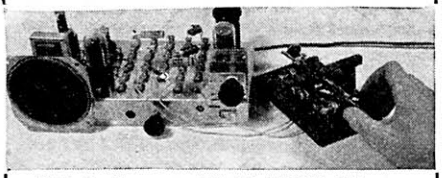
PRACTICAL TRAINING FM-RADIO-TV



Four fully-equipped laboratories provide the PRACTICAL training necessary for successful careers in Radio Communications (FCC licenses) and in Radio-Television (Technician) Servicing. Train under supervision of **technical specialists**—with COMMERCIAL-type equipment. Investigate why WRCI SPECIALIZED TRAINING methods are outstanding in the West; why WRCI **laboratory-trained** specialists are preferred for responsible positions. Read our illustrated bulletin before enrolling in any school. Approved for veteran training—non-veterans accepted. Send for free copy of Bulletin-A today.

WESTERN RADIO COMMUNICATIONS INSTITUTE
631 West Ninth Street, Los Angeles 15, California

Get a new
ELECTRIC SOLDERING IRON
FREE
. . and assemble your own
MAGI-KLIPS
RADIO & ELECTRONIC EXPERIMENTER'S KIT



This is the same **MAGI-KLIPS** Kit—complete with all parts—that we sell ready assembled for $29.75.

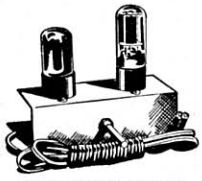
In knocked-down form with full instructions for assembly, it is now available at the **new low price—**

$19.75

. . . complete with a new Electric Soldering Iron—the ideal iron for wiring your unassembled **MAGI-KLIPS** Kit.

Remember, you build 18 different experiments with your **MAGI-KLIPS** Kit. You actually teach yourself radio and electronics and have a lot of fun at the same time.

RADIO RECEIVER, HOME BROADCASTER, PHOTO-ELECTRIC RELAY, CODE PRACTICE OSCILLATOR, SIGNAL TRACER, REMOTE CONTROL RELAY, Phonograph Transmitter, Intercommunication Amplifier, Code Transmitter, Radio Frequency Oscillator, Telephone Line Amplifier, Electronic Switch, Phonograph Amplifier, Temperature Control Relay, Contact Detector, Electronic Metronome, Interval Timer (one-shot), Interval Timer (repeating).



PHONO-AMPLIFIER KIT. A real bargain. Uses 35Z5 and 50L6. Complete diagram and instructions for assembling. Also good for call system.

Kit Form $1.85
Wired and Tested. 2.45
Tubes for above. . 1.65

CODE PRACTICE OSCILLATOR KIT
Learn the code! Get your ham ticket! Uses 50L6, 35Z5, 4" PM speaker. Tone and volume controls. Ideal for classroom instruction. Complete diagram and assembly instructions.

Kit Form $2.85
Speaker and Transformer for above. 1.95
Tubes for above. 1.65
Wired and Tested, with Tubes and Speaker 6.00

Terms: 20% deposit, balance C.O.D.
Send for your copy of FREE booklet, "ELECTRONICS MADE EASY"

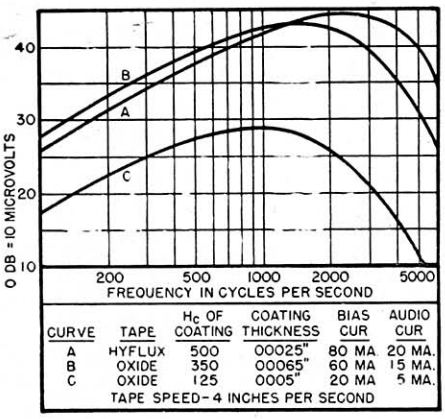
DEER & TAYLOR COMPANY
Dept. N 1342 Milvia St. Berkeley 9, Calif.

NOW AVAILABLE!
Amplifier for GE pickup



New circuits for the first time enable you to attain full benefit from the new General Electric Model DL 1RM 6C Variable Reluctance Magnetic pickup. Employs an exclusive, humless (DC on heaters) pre-equalized pre-amplifier to produce the most satisfying musical amplifier the world has ever known. If you are a perfectionist, you are the one for whom the ACA-100GE was designed. Send for technical literature.

AMPLIFIER CORP. of AMERICA
398-2 Broadway, New York 13, N. Y.



CURVE	TAPE	Hc OF COATING	COATING THICKNESS	BIAS CUR	AUDIO CUR
A	HYFLUX	500	00025"	80 MA	20 MA.
B	OXIDE	350	00065"	60 MA	15 MA.
C	OXIDE	125	0005"	20 MA	5 MA.

TAPE SPEED-4 INCHES PER SECOND

Fig. 13. Response curve similar to that shown in Fig. 12 with the exception that tape speed has been reduced from 8 to 4 inches-per-second. Curves B and C show results using oxide-coated tape.

work for low frequency adjustment is shown in Fig. 11. The low frequencies are boosted about 15 db. maximum at 100 c.p.s. Fig. 12 is typical of constant current response at 8" per second. The response at a tape speed of 4" per second is shown in Fig. 13.

(Ed. Note: Standards for tape and heads have not, at this date, been adopted. The above data applies, in general, to other heads and to tapes of similar characteristics.)

(To be continued)

Tape Systems

(Continued from page 46)

30 kc. bias current and the audio frequency which is being recorded. For proper functioning, the 30 kc. potential across the recording head should range from 60 to 100 volts as measured with an a.c. vacuum tube voltmeter having a minimum input impedance of 10 megohms.

A visual recording indicator is provided, see Section F, employing a type 6E5 tube. It is used as a volume indicator when recording. It receives an audio voltage from the screen of the 6SJ7 second record-amplifier tube. The screen of the tube is used as the source of this indicating voltage so that the audio voltage present will be the only actuator of the volume indicator. Since the 30 kc. bias current is available in the plate circuit, the plate could not be used as a source of audio voltage alone for the indicator.

The 30 kc. supersonic oscillator (Section Y) employs a 6SN7, the first half of which is used in the oscillator circuit. The quality of this tube is critical and only one with a very high reading on a mutual conductance type tube tester should be employed. It may be necessary to interchange this tube with others of the same type to obtain best results. The bias current originated in this oscillator stage is, after proper amplification, used for the erasure as well as the recording bias.

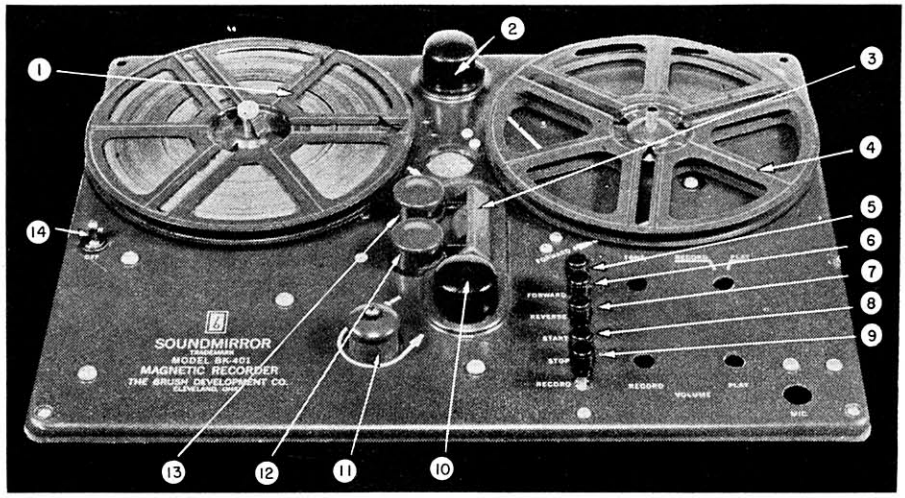
A push-pull erase amplifier is employed (see Section H) using the two triodes of a type 6SN7 tube. These are connected to form a push-pull amplifier which receives its driving signal from Section Y. During the recording operation the plate-to-plate potential in this stage ranges between 80 and 100 volts and results in a 30 kc. current through the erase head coil of approximately 20 ma.

A conventional phase inverter stage is utilized (Section J) which provides the signal for the final amplifier stage. Either a 6SL7 or a 6SN7 may be used in the phase inverter position. When a 6SN7 is employed the grid resistor should be 22,000 ohms. If a 6SL7 is used, the same resistor should have a value of 33,000 ohms. It may be desirable, in equipment using the 6SL7, to replace it with a 6SN7 with a proper grid resistor since this substitution may reduce possible microphonics. A "Class A" push-pull audio amplifier stage (Section K) using a type 6SN7 is self-explanatory.

The principal components are shown in Fig. 3, as well as the selector push-buttons.

-30-

Fig. 3. Top view of Brush "Soundmirror" tape recorder. Keyed parts are: (1) Supply reel; (2) Reverse limit switch; (3) Brake shoe for head; (4) Takeup reel; (5) Forward push-button; (6) Reverse push-button; (7) Start push-button; (8) Stop push-button; (9) Record push-button; (10) Forward limit switch; (11) Drive capstan; (12) Record-reproduce head; (13) Erase head; and (14) On-off toggle switch.



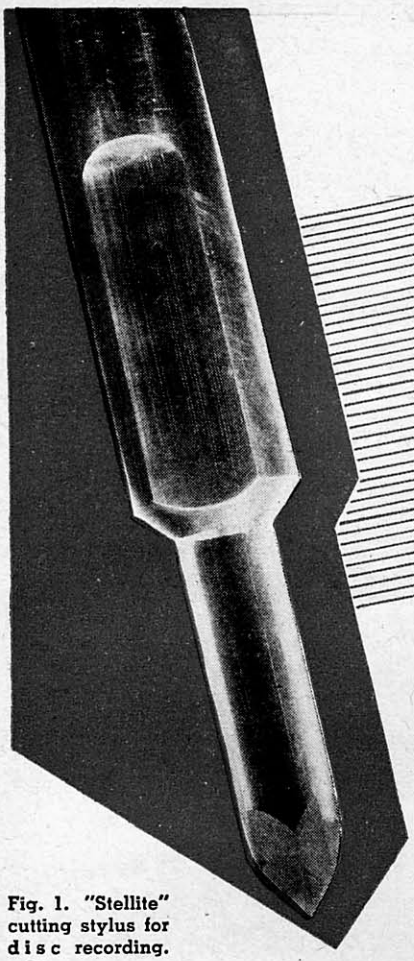


Fig. 1. "Stellite" cutting stylus for disc recording.

The RECORDING and REPRODUCTION of SOUND

By
OLIVER READ
Editor, RADIO NEWS

Part 13. A discussion of the characteristics of cutting styli and conditions governing their proper use.

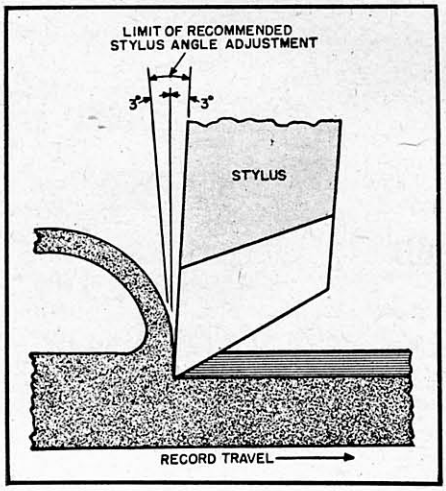
THERE are, in general, three basic types of recording styli in present use. These are: the sapphire, alloy, and steel. The cutting stylus acts in the same manner as does the tool which cuts into material on a revolving lathe. As a matter of fact, the cutting stylus is shaped somewhat like a lathe tool. There is one basic difference, however—the tip of the stylus is the only portion of the assembly which does any actual cutting. For that reason, only the tip need be of hardened material. Normally the stylus cuts a groove in the record of approximately .003 inch in depth. Obviously only that part of the stylus within .003 inch of the tip is subjected to wear. The remainder of the stylus is known as the shank. This is the supporting and enclosing medium which serves merely as the connecting link between the cutting head armature and the portion of the stylus which does the cutting.

It is of major importance that standards be met when manufacturing a stylus for the recording of a sound track in a disc. Not only must the cutting edges of the stylus tip be extremely sharp and free from imperfections, but the sides of the tip must be polished to a very smooth surface. If the cutting edges are not sharp the chip will literally be torn from the blank instead of being cut with a clean stroke as illustrated in Fig. 2. The result will be a groove that is noisy. If the sides of the stylus tip are not polished, groove and stylus cuts will be rough and these will cause undue noise in the recording. Therefore, the groove, after being cut by the stylus, should actually shine (Fig. 4). This indicates that a properly polished and sufficiently sharp stylus has been used. A dull finish on the sides and bottom of the groove indicates that a stylus has been used which is unduly worn or which is otherwise defective.

Most recorders today, except for the inexpensive home recorders, employ a sapphire cutting stylus. These require a high degree of workmanship. If the stylus is inaccurately ground and improperly polished it will not give good results. In fact, results will be inferior to those achieved with a new steel stylus of quality manufacture.

The cutting life of a stylus depends upon several factors; first, the hardness of the material on the blank and second, the lineal velocity of the record groove. For example, a stylus will cut longer when cutting twelve inch records at 33⅓ r.p.m. than when cutting the same diameter at 78 r.p.m. This is because the heat generated at the stylus tip becomes greater as the speed increases.

Fig. 2. Stylus angle adjustment.



Sapphire styli may be made from the genuine gem or from synthetic sapphire (aluminum oxide). The gem sapphire is slightly more expensive but will have longer cutting life before requiring repolishing and resharpening. Both genuine and synthetic styli of this type take a high polish, a feature which is of extreme importance. They both have a low coefficient of friction and are very hard.

Sapphire styli may be resharpened many times and will give many hours of trouble-free service. Because of this long life and because they can be resharpened at a fraction of their initial cost, these styli are no more expensive to use than other types. The chief disadvantage is their fragility. The sapphire is quite brittle and very hard. This means that the tip of the sapphire can be easily chipped. A dulled sapphire can be resharpened but a chipped one cannot. When chipping occurs, the stylus must be discarded.

The tiny tip material is enclosed and mounted in a tubular metal shank. The mounting of these tiny points is extremely critical. There must be no side play, that is, the stylus tip must be firmly embedded into the shank where it cannot assume any motion other than that presented from the armature in the cutting head. The better the bond between the shank and stylus tip, the better

will be the high frequency response. The sapphire must, accordingly, be handled with great care. To accidentally drop the stylus onto a disc is disastrous. Chances are the tip will be ruined.

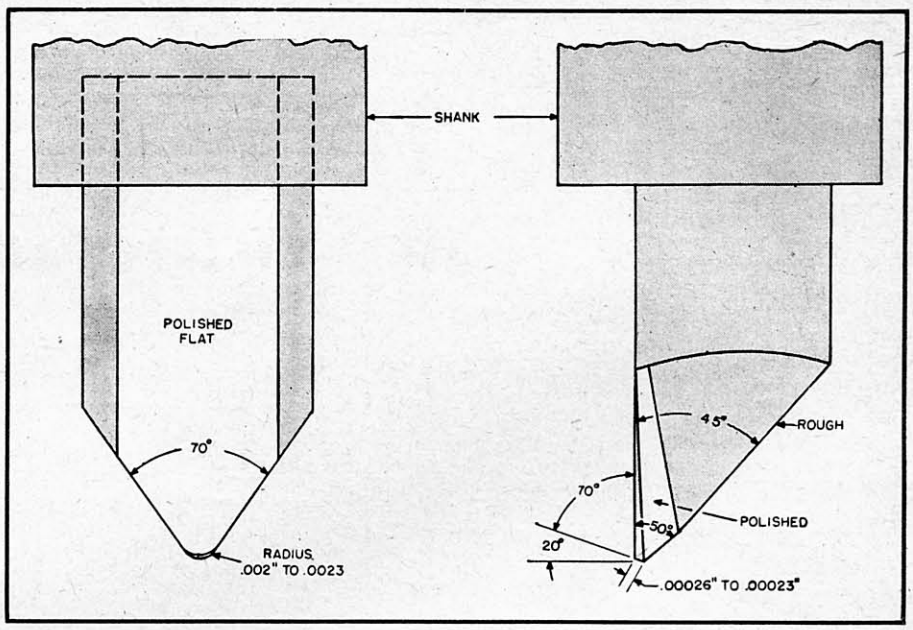
A tremendous strain is placed upon the edges of the recording stylus as it cuts the record groove. The amount of surface noise will depend largely upon the ability of the stylus to retain a sharp edge. In other words, the sharper the edge, the quieter will be the resulting recording. If the edges are dull, the result will be a tearing of the disc material in the groove and the background noise will increase materially. It is, therefore, highly important that the cutting edges be extremely sharp in order that all high frequency undulations be properly impressed on the groove walls. The humps in the vibration waves will vary according to frequency. The low notes or tones will have humps which appear farther apart within the groove than will the high frequency tones or notes. This condition is aggravated where high frequencies appear at low record groove diameters. This is still another reason for using only the best material for the cutting stylus. Furthermore, if sharp edges are not retained, the soft plastic material on the disc will tend to flow instead of being cut properly. Such a condition will result in a recording which sounds mushy or distorted.

Various attempts have been made, some with great success, to develop a cutting stylus making use of an alloy. Usually these styli have a brass or dural shank and only the tip is of the cutting alloy. Some of these styli, using hard material, will last almost as long as a good sapphire. The cost is considerably less however. The chief disadvantage is that these styli have considerably more surface noise than the sapphire and therefore most of the more popular alloy tipped cutting styli employ a metal somewhat softer than the sapphire in order to facilitate proper shaping of the tip and to thereby obtain a lower coefficient of friction. One of these is known as a *"Stellite"* which is tipped with a metal bearing that name (see Fig. 1). It is capable of cutting records for approximately two hours. It may be resharpened for about one-half the cost of a new unit. There is little or no danger of this type of stylus chipping, which is the main reason for its popularity. It is particularly well suited for the home recordist as the hazards of ruining a good cutting stylus are greatly reduced. There are many alloy materials employed for a cutting stylus. These are known as "precious metal tipped styli." One is about as good as another and, as previously mentioned, they are ideally suited to the home recordist.

Steel Styli

The most inexpensive material to use for a cutting stylus is ordinary hard polished steel. There is little hazard from damage when employing such styli. Their life is extremely limited and, figured on a service-per-hour basis, steel styli are actually more expensive than sapphires. They cost from about twenty-five cents to seventy-five cents each and have a useful life of approximately thirty minutes.

For the first few seconds they will possess a very sharp, keen cutting edge. However, they dull quickly and the recording gradually becomes quite



Essential dimensions of sapphire cutting stylus used for lateral recording.

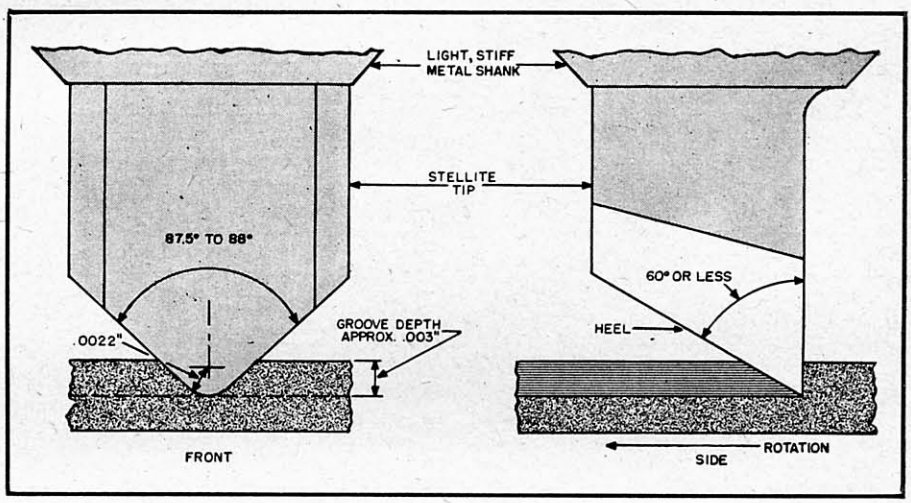
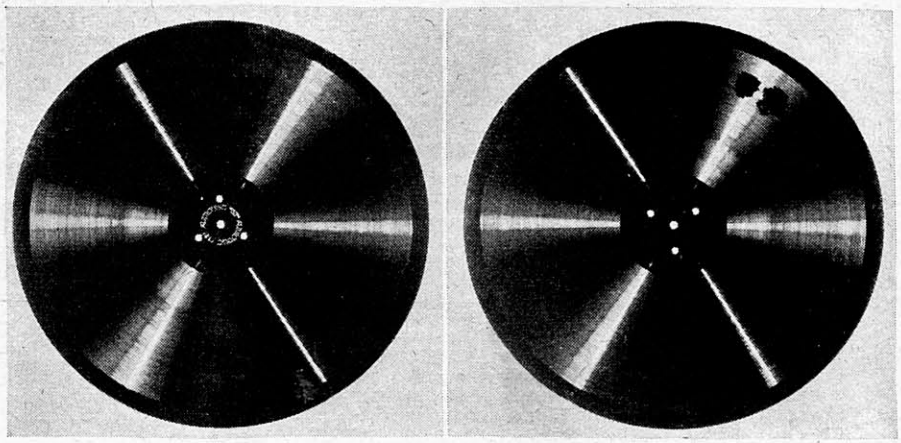


Fig. 3. Essential dimensions for steel or "Stellite" cutting stylus.

Fig. 4. Record cut with new stylus (left). Effects of cutter bounce (right).



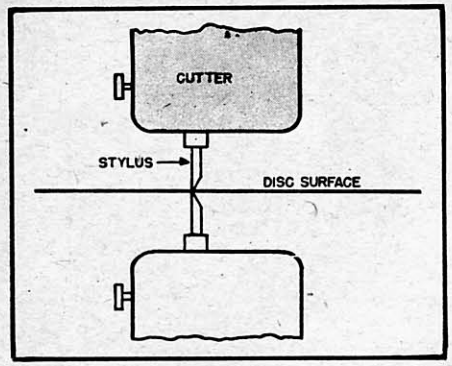


Fig. 5. Correct cutting angle of a stylus may be checked by viewing the reflection of the cutting stylus on the shiny surface of an uncut blank when the turntable is in a stationary state.

noisy. The response of a steel stylus is not as good as a sapphire and it is not capable of engraving the high notes comparable to a sapphire. However, the response is sufficiently good to handle speech and general home music where the highest overtones are not appreciated. Steel styli cannot be resharpened or polished and must be discarded after about thirty minutes of use.

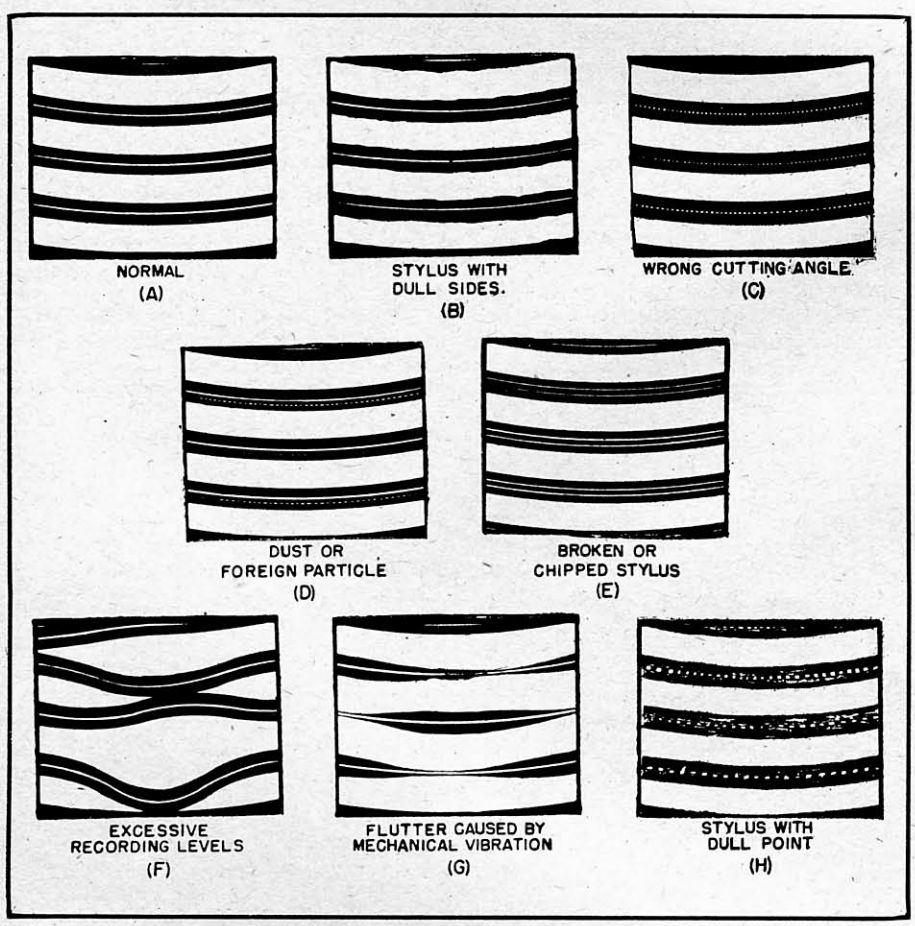
Cutting Angle

The correct cutting angle for the stylus will depend upon the type of head used, the type of material being cut, and the angle on the face of the cutting stylus. If the cutting angle is not correct, there will be an appreciable increase in surface noise. In addition, difficulty will be encountered in controlling the thread or chip as it leaves the record from the cutting process. The result will be high surface noise and squeaking. Many recordists prefer a slight "dig in." This means that the cutting face of the stylus leans slightly forward. Others insist the best results can be obtained only when a slight amount of "dig out" is employed, that is, when the cutting face leans slightly backward from vertical. There is no specific rule of thumb for the correct cutting angle of the stylus. The correct position can be most accurately determined only by cut and try. A test record should be cut without modulation. The unmodulated grooves should be shiny and free from any dullness when viewed in direct light. The record may be played back with a known quality reproducing stylus and the listening test will determine whether or not the cutting has been properly done. If, when played back through an amplifier, there is undue hiss, noise, or squeak on the record it will indicate that an incorrect cutting angle has been employed.

Usually, with good equipment, a correct cutting angle will be found within two or three degrees of a ninety degree vertical. The cutting angle applies whether the cutting face of the stylus leans forward or backward. It does not depend on whether the face is turned one way or another, that is, from side to side. The cutting face of the stylus is pitched slightly as an aid in throwing the chip toward the center of the record. This pitch angle is rarely more than about two degrees. The normal tendency is for the scrap or chip material to fall to the inside of a revolving disc rather than to the outside, therefore, a slight pitch is employed as an aid in steering the chip toward the center of the disc. The cutting angle or angle which the cutting face makes with the surface of the record is checked by viewing the reflection of the cutting stylus on the shiny surface of an uncut blank (Fig. 5) when the turntable is in a stationary position. By looking directly toward the side of the cutter, an imaginary straight line is viewed from the reflection of the stylus both above and below the surface. If there appears to be a continuous straight line, chances are that the stylus is close to the proper vertical position. Any deviation from a straight line will indicate a leaning forward or leaning back of the cutter and its associated stylus. In some cases the cutting face is not parallel to the shank of the stylus. Some manufacturers vary the angle of the face of the stylus considerably. Inasmuch as there are no standards at this writing, no specific stylus can be discussed as being the best suited for general recording purposes. It is well to heed the advice of the cutter manufacturer when selecting styli.

One high quality stylus has a seventy degree angle and employs a short shank. Another has a ninety degree angle and short shank and is recommended for use with a particular cutting head when recording on acetate-lacquer blanks. If a long shank stylus is used, records will be approximately two decibels louder for the same recording level but the frequency response will be poor beyond 8000 c.p.s. and a severe high frequency peak may develop in this region.

Characteristics of recorded grooves. All except (F) have been cut without modulation.

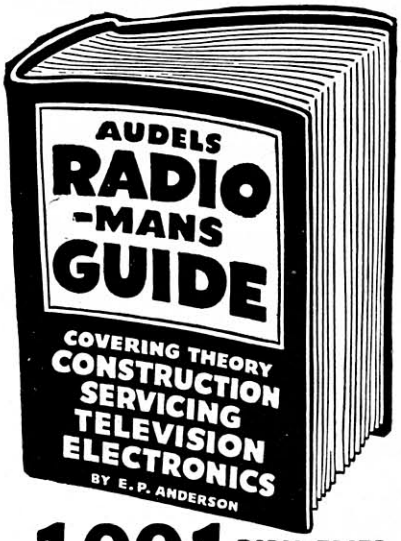


High Fidelity Recording

As mentioned in earlier paragraphs, steel or even tungsten styli can be used but they have a shorter life and are not usually satisfactory for high fidelity work, since in general they produce a groove having a higher noise level. Sapphire styli are recommended for all recording except unimportant tests. A sharp cutting stylus will remove the thread quietly and smoothly. The only noise should be that of the recorder head itself which "talks" audibly during the louder passages. In other words, when test cuts or blank grooves are cut, there should be no tearing or scraping sound. By placing the ear close to the record it is possible to hear the cutting which should sound even in character and have a faint steady hiss. The stylus can be adjusted for minimum noise while operating. The amount of noise heard while cutting a blank groove is a

(*Continued on page* 148)

PLEASE TEAR OUT THIS ADV. AS REMINDER



1001 RADIO FACTS AND FIGURES

AUDELS RADIOMANS GUIDE—914 Pages, 633 Illustrations, Photos, Wiring Diagrams, 38 Big Chapters, covering Radio Theory, Construction, Servicing, including Important Data on Developments in Television, Electronics and Frequency Modulation, Review, Questions and Answers, Calculations & Testing. Highly Endorsed—Indispensable for Ready Reference and Home Study.

$4 COMPLETE • PAY ONLY $1 A MONTH

Step up your own skill with the facts and figures of your trade. Audels Mechanics Guides contain Practical Inside Trade Information in a handy form. Fully Illustrated and Easy to Understand. Highly Endorsed. Check the book you want for 7 days' Free Examination.

Send No Money. Nothing to pay postman.

CUT HERE

MAIL ORDER

AUDEL, Publishers, 49 W. 23 St., NEW YORK 10, N. Y.

Please send me postpaid for FREE EXAMINATION books marked (x) below. If I decide to keep them I agree to mail $1 in 7 Days on each book ordered and further mail $1 monthly on each book until I have paid price —otherwise, I will return them.

- ☐ RADIOMANS GUIDE, 914 Pages $4
- ☐ ELECTRICIANS EXAMINATIONS, 250 Pages . 1
- ☐ WIRING DIAGRAMS, 210 Pages 1
- ☐ ELECTRIC MOTOR GUIDE, 1000 Pages . . . 4
- ☐ ELECTRICAL DICTIONARY, 9000 Terms . . 2
- ☐ ELECTRICAL POWER CALCULATIONS, 425 Pgs. 2
- ☐ HANDY BOOK OF ELECTRICITY, 1440 Pages 4
- ☐ ELECTRONIC DEVICES, 216 Pages 2
- ☐ ELECTRIC LIBRARY, 12 vol., 7000 Pgs., $1.50 vol.
- ☐ OIL BURNER GUIDE, 384 Pages 1
- ☐ REFRIGERATION & Air Conditioning, 1280 Pgs. 4
- ☐ POWER PLANT ENGINEERS Guide, 1500 Pages. 4
- ☐ PUMPS, Hydraulics & Air Compressors, 1658 Pgs. 4
- ☐ WELDERS GUIDE, 400 Pages 1
- ☐ BLUE PRINT READING, 416 Pages 2
- ☐ SHEET METAL WORKERS Handy Book, 388 Pgs. 1
- ☐ SHEET METAL PATTERN LAYOUTS, 1100 Pgs. 4
- ☐ AIRCRAFT WORKER, 240 Pages 1
- ☐ MATHEMATICS & CALCULATIONS, 700 Pgs. . 2
- ☐ MACHINISTS Handy Book, 1600 Pages . . . 4
- ☐ MECHANICAL Dictionary, 968 Pages 4
- ☐ AUTOMOBILE GUIDE, 1700 Pages 4
- ☐ DIESEL ENGINE MANUAL, 400 Pages . . . 2
- ☐ MARINE ENGINEERS Handy Book, 1280 Pages 4
- ☐ MECHANICAL DRAWING GUIDE, 160 Pages . 1
- ☐ MECHANICAL DRAWING & DESIGN, 480 Pgs. 2
- ☐ MILLWRIGHTS & Mechanics Guide, 1200 Pgs. 4
- ☐ CARPENTERS & Builders Guides (4 vols.) . . 6
- ☐ PLUMBERS & Steamfitters Guides (4 vols.) . 6
- ☐ MASONS & Builders Guides (4 vols.) 6
- ☐ MASTER PAINTER & DECORATOR, 320 Pgs. 2
- ☐ GARDENERS & GROWERS GUIDES (4 vols.) 6
- ☐ ENGINEERS and Mechanics Guides Nos. 1, 2, 3, 4, 5, 6, 7 and 8 complete . . . 12
- ☐ Answers on Practical ENGINEERING 1
- ☐ ENGINEERS & FIREMANS EXAMINATIONS . 1

Name _____

Address _____

Occupation _____

Employed by _____ RN

transformer is permeability tuned and its secondary is the tapped inductance for a Hartley oscillator using V_4 as the oscillator tube. The tank circuit is completed by C_5 and C_6, and the capacity of V_3 which is used here as a reactance tube. This oscillator circuit produces a sine wave which is changed into a saw-tooth wave by the discharge tube V_5. The frequency comparison takes place in the duodiode V_2 by means of the induced signal and the center-tapped primary. The error voltage is developed across R_4 and R_5 which go to a -2 volt tap in the power supply bleeder, and thus provides a fixed bias for the reactance tube V_3. When an error voltage is developed it adds or subtracts from the bias and therefore changes the capacity of the reactance tube. This, in turn, changes the frequency of the oscillator, producing the desired correction.

The problem of the serviceman is usually how to recognize a faulty a.f.c. system, since loss of sync is not necessarily due to the a.f.c. If, for instance, one of the sync amplifiers or the clipper is not functioning properly, no sync pulse may reach the discriminator and the a.f.c. cannot function. Usually only the horizontal sweep employs a.f.c., while the vertical works on direct sync, so that, when the picture does not seem to move up or down, it is safe to assume that the portions of the clipper and sync amplifier which contain both horizontal and vertical pulses, are all right and the trouble must, therefore, be in a section containing only the horizontal pulse. On the other hand, if it appears impossible to get either the vertical or the horizontal into sync, then obviously it cannot be the fault of the a.f.c., and the trouble is probably in the clipper or amplifier. A good oscilloscope will permit tracing the sync pulses through the circuit and thereby greatly facilitate trouble-shooting. This fact has been recognized by most television service organizations which invariably possess and use suitable scopes.

In conclusion it may be said that it is very desirable to have a.f.c. in the horizontal sweep circuits of the more expensive television receivers, especially those having a screen diameter of 10 inches and up, to facilitate adjustment and prevent "tearing" and loss of sync due to noises or unstable oscillators. A disadvantage of a.f.c. is the need for at least four additional tubes, although this is usually minimized by using one duodiode and a duo-triode. However, the added number of components and necessary adjustment in production do mean added expense. Servicing problems with regards a.f.c. systems are greatly reduced when the trouble is located in one particular section by judging the symptoms and deducing their causes. Once a serviceman gets better acquainted with the appearance of sync trouble, he will have no difficulty locating and repairing it.

—30—

Recording of Sound

(*Continued from page* 64)

fairly reliable indication of how much surface noise will exist in the finished record.

Recording Levels

Considerable experience and skill is required in order for the recordist to obtain top quality results from his recordings. It is not practical to make an exact statement of the correct operating level for any particular recording head or setup. The correct level can be established only by experience and test. There are no fixed boundaries in disc recording representing 100% modulation. At low frequencies the groove spacing limits the possible amplitude of the cutter. At high frequencies the radius of turning of the groove is the limiting factor.

It is not difficult to find the correct operating levels for a complete installation if test cuts of speech and music are made at the same standard record speeds using the smallest contemplated groove diameters. These test cuts should be made at gradually increasing levels and the results should be noted when the records are reproduced. When the reproduction ceases to be acceptable from a quality standpoint, the maximum level has been exceeded. The presence of a very small amount of distortion is sometimes less objectionable than excessive surface noise which is one reason, from a practical commercial standpoint, for not being guided too strictly by measured distortion. It is well to keep in mind what type of equipment will be used to reproduce the recorded material. Only the most advanced type of pick-up with a diamond or sapphire stylus should be used if best quality of reproduction with low noise level is desired from acetate type recordings.

Records for 33⅓ r.p.m. cannot be cut at as high a level as records for 78 r.p.m. because of the reduced surface velocity of the record material. It is equally necessary to reduce the recording level at least 6 db. on the 33⅓ r.p.m. discs. A higher level is usually used for 33⅓ r.p.m. lacquer master discs for processing than for recordings where the original is to be played back repeatedly. A high level soft lacquer original will not withstand repeated playbacks. However, the surface noise with these discs is low so that there is no need for the maximum level.

All disc recordings suffer from loss of high frequency response during playback in the area nearer the center of the disc. As the diameter of the record grooves become smaller, the condition becomes progressively worse because of the reduction in the linear speed of the recorded groove. With the slower groove speed, the actual linear distance

Better Products for the Radio Industry

FIELD CHASS EZ—STATION INJECTOR AND POWDER—REPAIR KIT—DELUXE HARDWARE LABORATORY

G-C FIELD CHASS EZ



PAT. PEND.

Holds almost any radio chassis in position! Has special reversible hooks for flanged type chassis, or to tilt chassis back if necessary. Made with slide adjustment—takes only 5 seconds to install. No parts to lose—will never wear out. A real convenience for the radio serviceman!
No. 5207—Servicemen's Kit.....$2.95



G-C MASTER DELUXE CABINET REPAIR KIT

Complete kit in permanent metal box. Contains shellac, alcohol lamp, varnishes, glue, enamels, polish, directions, etc.
No. 900—List $8.75

NEW G-C STATIC CHASER INJECTOR AND POWDER



Tire static powder kits . . . improve auto radio reception. Eliminate wheel static interference. New powder is blown into all inner tubes, easy to use. For every car owner!

No. 5604—Injector for G-C Static Powder .....List $1.50
No. 5605—G-C Static Powder Packet for 5 tires.....List $1.00
No. 5606—Kit—Powder Packet and Injector .....List $2.50

G-C COMPLETE HARDWARE LABORATORY



40 jars of over 2100 essential electronic hardware items, screws, nuts, lugs, parts, etc. . . . all the items you need.
No. 6604—
List....$24.00



Have you seen the new G-C "Speedex" Wire Strippers . . . write for illustrated literature.
RADIO DIVISION, DEPT. H

G-C Products are available at leading distributors. Write for your copy of our new illustrated catalog.

GENERAL CEMENT Mfg. Co., Rockford, Ill., U. S. A.
Manufacturers of over 3,000 products • Sales offices in principal cities

ELECTRONIC SPECIALTIES
for hams for FM for TV

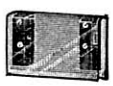
MOSLEY ANTENNA ATTACHMENTS



DIPOLE CONNECTOR
(Catalog 25-C)



END INSULATOR
(Catalog 25-E)



ANTENNA RAINCOAT
(Catalog 26)
Covers center connections and keeps them dry. Reduces change in impedance match.



CABLE PLUG
(Catalog 300-P)
For dead-ending 300 ohm transmission line.

These MOSLEY ANTENNA ATTACHMENTS are for 300 ohm transmission line and support antenna and feeder line securely. NO SOLDER IS NEEDED.

Also completely assembled ANTENNAS and KITS

MOSLEY CRYSTAL HOLDER ADAPTERS

(Catalog 5-75)



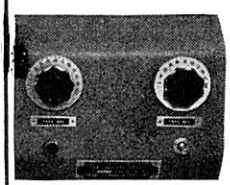
Fits ½" crystal holder to ¾" spacing.



(Catalog 75-5)
Fits ¾" crystal holder to ½" spacing.

FOR SALE
AT YOUR NEAREST JOBBER
CARL E. MOSLEY
(WØFQY)
2125 LACKLAND ROAD OVERLAND 14 MO.

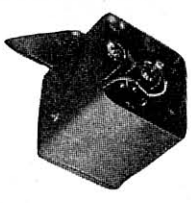
TELEVISION—F. M. TEST GENERATOR FOR $29.75!



Does the work of sweep generators three times this price. This quality product is guaranteed and is indeed a substantial contribution to the industry. Note these features of the Model H.G.-2 signal generator.

- Frequency range: From 5 mc. thru F.M. and television bands.
- Full range attenuation control.
- Synchronizing voltage for locking in pattern on oscilloscope.
- Produces a rapid response curve of your I. F. strip or F. M. and television receiver, providing quick visual alignments at low cost.

HI-VOLT (R. F. TYPE) POWER SUPPLY



For television and similar applications. It's small—safe—superbly engineered.
3000-6000 V. 4"x4"x5".
Model H.V.-6.....$14.95
Model H.V.-6 kit..... 12.50
Model H.V.-6 coil..... 5.75
6000-10,000 V. 4"x6"x6".
Model H.V.-10..... 19.95
Model H V.-10 kit..... 16.95
Model H.V.-10 coil..... 7.75
Diagram furnished with each coil.

GOVERNMENT SURPLUS

COIL SETS for CBY receivers of RU 12 equipment single range $0.50; dual range $0.75; specify frequency desired.
TUBING—High grade red flexible tubing for No. 20 wire, 1500 ft. roll $4.95.
B.C. 423 SIGNAL GENERATOR modified for R.F. tuning of television and F.M., Pulse modulated. 54 to 106 mc. $19.95.
B.C. 403 RECEIVER complete with 15 tubes. Easily modified for 2 meters. $19.95.
FEED THRU INSULATORS—Heavy duty porcelain bell type 6"x 9" $2.50.
CRYSTALS 1N21 and 1N23, 3 for $1.00.
B.C. 412 SCOPES. Easily converted to television sets, and test scopes; only a few left, $39.50.
CRYSTALS 100 K.C. high precision type. Frequency stability ± 15 cycles from −50° to +80° C. $4.50.
ALUMINUM CASES 10"x14"x21" for scopes, television, mobile rigs, etc. with punched front panel and chassis. Well ventilated, new Duco finish $4.95.
25% with C.O.D. orders. Surplus F.O.B. Hempstead. $2.00 min.

ALGERADIO 385 Jackson Street, Hempstead, N. Y.

available for a complete cycle of, for example, a 10,000 c.p.s. tone, becomes very short. The cutting stylus has a front face which is a flat plane and can record the high frequencies at the slower groove speeds without difficulty. The limiting factor becomes apparent when an attempt is made to reproduce this recording. The reproducing stylus must have a tip of spherical shape. It is obvious that this tip cannot follow a recorded groove whose radius of turning is less than the radius of the stylus tip. It is therefore desirable to confine high fidelity recording to large diameters, dividing the time on two or more discs if necessary for maximum quality. Records having extended frequency range cannot be made at a diameter of less than nine inches for 33⅓ r.p.m. without an extreme loss of high frequency response.

In making high fidelity records, including discs for immediate playback, use can be made of what is a known as complimentary compensation. Because of the energy distribution in most speech or music it is possible to accentuate the higher frequencies when making a record and then to attenuate these frequencies by a like amount in reproduction, thereby reducing the surface noise resulting from minute foreign particles in the record stock.

For high quality recordings the frequency rise should begin at about 700 c.p.s. and should increase smoothly to a maximum of 16 db. at 10,000 c.p.s. Filters, such as the *RCA* orthocoustic recording filter MI-4916, have been designed for this purpose. In reproduction the inverse of this rise should be employed. Pre- and post-equalization, as this method of compensation is often called, results in a substantial reduction of surface noise. Another form of high frequency compensation involves the use of automatically variable equalizers designed specifically for 33⅓ r.p.m. recording. With these devices the high frequency compensation is progressively increased as the recording groove diameter becomes smaller. The equalizer mounts on the rear of the recorder mechanism and is synchronized with the cutter head so that the amplifier gain is increased at the high frequencies to an amount which is considered a practical maximum.

Record playing time. Note that 17¼ inch blanks used for recording the "masters" should be recorded as 16 inch blanks.

Grooves Per Inch	Turntable Speed r.p.m.	Approximate Playing Time (minutes)		
		16-inch Record	12-inch Record	10-inch Record
96	78	6½	4	2¾
112	78	7½	4½	3¼
120	78	8	5	3½
136	78	9	5½	3¾
154	78	10	6	4
96	33⅓	14	8	4¼
112	33⅓	16	9¼	6
120	33⅓	17	9¾	6
136	33⅓	18	10	6
154	33⅓	20	11	6½

Better Products for the Radio Industry

FIELD CHASS EZ—STATION INJECTOR AND POWDER—REPAIR KIT—DELUXE HARDWARE LABORATORY

G-C FIELD CHASS EZ



Holds almost any radio chassis in position! Has special reversible hooks for flanged type chassis, or to tilt chassis back if necessary. Made with slide adjustment—takes only 5 seconds to install. No parts to lose—will never wear out. A real convenience for the radio serviceman!
No. 5207—Servicemen's Kit.....$2.95

NEW G-C STATIC CHASER INJECTOR AND POWDER



Tire static powder kits . . . improve auto radio reception. Eliminate wheel static interference. New powder is blown into all inner tubes, easy to use. For every car owner!

No. 5604—Injector for G-C Static Powder .....List $1.50
No. 5605—G-C Static Powder Packet for 5 tires.....List $1.00
No. 5606—Kit—Powder Packet and Injector .....List $2.50



G-C MASTER DELUXE CABINET REPAIR KIT

Complete kit in permanent metal box. Contains shellac, alcohol lamp, varnishes, glue, enamels, polish, directions, etc.
No. 900—List $8.75

G-C COMPLETE HARDWARE LABORATORY



40 jars of over 2100 essential electronic hardware items, screws, nuts, lugs, parts, etc. . . . all the items you need.
No. 6604—
List....$24.00



Have you seen the new G-C "Speedex" Wire Strippers . . . write for illustrated literature.
RADIO DIVISION, DEPT. H

G-C Products are available at leading distributors. Write for your copy of our new illustrated catalog.

GENERAL CEMENT Mfg. Co., Rockford, Ill., U. S. A.
Manufacturers of over 3,000 products • Sales offices in principal cities

ELECTRONIC SPECIALTIES
for hams for FM for TV

MOSLEY ANTENNA ATTACHMENTS



DIPOLE CONNECTOR
(Catalog 25-C)



END INSULATOR
(Catalog 25-E)



ANTENNA RAINCOAT
(Catalog 26)
Covers center connections and keeps them dry. Reduces change in impedance match.



CABLE PLUG
(Catalog 300-P)
For dead-ending 300 ohm transmission line.

These MOSLEY ANTENNA ATTACHMENTS are for 300 ohm transmission line and support antenna and feeder line securely. NO SOLDER IS NEEDED.

Also completely assembled ANTENNAS and KITS

MOSLEY CRYSTAL HOLDER ADAPTERS



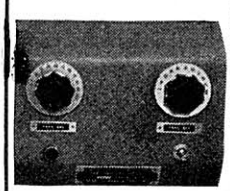
(Catalog 5-75)
Fits ½" crystal holder to ¾" spacing.



(Catalog 75-5)
Fits ¾" crystal holder to ½" spacing.

FOR SALE AT YOUR NEAREST JOBBER
CARL E·MOSLEY
(WØFQY)
2125 LACKLAND ROAD OVERLAND 14 MO.

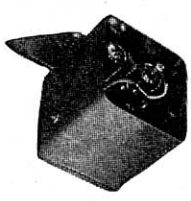
TELEVISION—F. M. TEST GENERATOR FOR $29.75!



Does the work of sweep generators three times this price. This quality product is guaranteed and is indeed a substantial contribution to the industry. Note these features of the Model H.G.-2 signal generator.

- Frequency range: From 5 mc. thru F.M. and television bands.
- Full range attenuation control.
- Synchronizing voltage for locking in pattern on oscilloscope.
- Produces a rapid response curve of your I. F. strip or F. M. and television receiver, providing quick visual alignments at low cost.

HI-VOLT (R. F. TYPE) POWER SUPPLY



For television and similar applications. It's small—safe—superbly engineered.

3000-6000 V. 4"x4"x5".
Model H.V.-6.....$14.95
Model H.V.-6 kit..... 12.50
Model H.V.-6 coil..... 5.75
6000-10,000 V. 4"x6"x6".
Model H.V.-10..... 19.95
Model H V.-10 kit..... 16.95
Model H.V.-10 coil..... 7.75
Diagram furnished with each coil.

GOVERNMENT SURPLUS

COIL SETS for CBY receivers of RU 12 equipment single range $0.50; dual range $0.75; specify frequency desired.
TUBING—High grade red flexible tubing for No. 20 wire, 1500 ft. roll $4.95.
B.C. 423 SIGNAL GENERATOR modified for R.F. tuning of television and F.M., Pulse modulated. 54 to 106 mc. $19.95.
B.C. 403 RECEIVER complete with 15 tubes. Easily modified for 2 meters. $19.95.
FEED THRU INSULATORS—Heavy duty porcelain bell type 6"x 9" $2.50.
CRYSTALS 1N21 and 1N23, 3 for $1.00.
B.C. 412 SCOPES. Easily converted to television sets, and test scopes; only a few left, $39.50.
CRYSTALS 100 K.C. high precision type. Frequency stability ± 15 cycles from −50° to +80° C. $4.50.
ALUMINUM CASES 10"x14"x21" for scopes, television, mobile rigs, etc. with punched front panel and chassis. Well ventilated, new Duco finish $4.95.
25% with C.O.D. orders. Surplus F.O.B. Hempstead. $2.00 min.

ALGERADIO 385 Jackson Street, Hempstead, N. Y.

available for a complete cycle of, for example, a 10,000 c.p.s. tone, becomes very short. The cutting stylus has a front face which is a flat plane and can record the high frequencies at the slower groove speeds without difficulty. The limiting factor becomes apparent when an attempt is made to reproduce this recording. The reproducing stylus must have a tip of spherical shape. It is obvious that this tip cannot follow a recorded groove whose radius of turning is less than the radius of the stylus tip. It is therefore desirable to confine high fidelity recording to large diameters, dividing the time on two or more discs if necessary for maximum quality. Records having extended frequency range cannot be made at a diameter of less than nine inches for 33⅓ r.p.m. without an extreme loss of high frequency response.

In making high fidelity records, including discs for immediate playback, use can be made of what is a known as complimentary compensation. Because of the energy distribution in most speech or music it is possible to accentuate the higher frequencies when making a record and then to attenuate these frequencies by a like amount in reproduction, thereby reducing the surface noise resulting from minute foreign particles in the record stock.

For high quality recordings the frequency rise should begin at about 700 c.p.s. and should increase smoothly to a maximum of 16 db. at 10,000 c.p.s. Filters, such as the *RCA* orthocoustic recording filter MI-4916, have been designed for this purpose. In reproduction the inverse of this rise should be employed. Pre- and post-equalization, as this method of compensation is often called, results in a substantial reduction of surface noise. Another form of high frequency compensation involves the use of automatically variable equalizers designed specifically for 33⅓ r.p.m. recording. With these devices the high frequency compensation is progressively increased as the recording groove diameter becomes smaller. The equalizer mounts on the rear of the recorder mechanism and is synchronized with the cutter head so that the amplifier gain is increased at the high frequencies to an amount which is considered a practical maximum.

Record playing time. Note that 17¼ inch blanks used for recording the "masters" should be recorded as 16 inch blanks.

Grooves Per Inch	Turntable Speed r.p.m.	Approximate Playing Time (minutes)		
		16-inch Record	12-inch Record	10-inch Record
96	78	6½	4	2¾
112	78	7½	4½	3¼
120	78	8	5	3½
136	78	9	5½	3¾
154	78	10	6	4
96	33⅓	14	8	4¼
112	33⅓	16	9¼	6
120	33⅓	17	9¾	6
136	33⅓	18	10	6
154	33⅓	20	11	6½

The term "flutter" is used to describe a vertical wave or oscillation which is sometimes cut in the recorded groove. This condition can often be seen as a series of radial spokes or patterns in the record surface. These patterns are usually visible before the record is reproduced although sometimes they may be seen more plainly after playing. When viewed through a microscope, this condition appears as an alternating change in width of the cut groove. Flutter may be caused by a building vibration, low frequency turntable rumble, incorrect stylus angle or a blank having an unusually wavy surface. Hard spots in a blank will result in a condition similar to that caused by flutter. As the stylus passes over harder and softer portions of the surface, the cutter head is raised or lowered slightly, causing a variation in the depth of groove. This variation should not be mistaken for flutter or oscillation since it is the original action of a well designed and free acting recording head. A distinctive characteristic of hard spots is their prevalence near the outside of the blank. Therefore, variations in groove depth due to hard spots will be more prevalent in this region.

Bouncing

When a valley is encountered when cutting a disc, bouncing will occur due to lack of sufficient pressure from the cutter and stylus. The result is illustrated in Fig. 4.

Cutter Adjustments

It is important that the feed screw mechanism be adjusted so that the carriage supporting the recording head travels in a plane exactly parallel to the surface of the turntable in order that the depth of cut will be uniform over the entire record surface. The front face of the stylus, when in the cutting position, should be adjusted to within plus or minus three degrees of perpendicular. Some experiment may be necessary to find the most satisfactory angle for any given surface material. It is advisable not to stop the turntable with the recording head in cutting position since the stylus may cut through the acetate coating to the metal core of the blank. This will chip the cutting edge of the stylus when the turntable is moved or the head raised.

Tests

It is good practice to make surface noise tests from time to time with all of the cutting styli available. This will assist the operator in selecting only those cutters which produce clean, quiet grooves. Present standards require the noise level on lacquer records to be down 50 db. from normal recording level. When checking noise it is necessary to refer the noise level to some standard level. It is suggested that the 1000 c.p.s. tone band of a standard tone record be selected as a reference level.

To determine the noise level, con-



The greatest RADIO HANDBOOK

WE'VE EVER PUBLISHED. Our 11th edition contains the greatest array of practical radio equipment ever shown between the covers of one book—all brand-new. All newly-designed, and newly-built by practical men, for practical men; all tested in our own shop in actual use. Larger-sized, more detailed photographs, on new larger page size (same size as this magazine).

FEATURED IN THIS EDITION ARE:

- Dozens of transmitters for all bands, and all powers up to 1 kw.
- Six chapters on Antennas, Transmission Lines, and Propagation
- One chapter devoted entirely to rotary array construction and feed methods.
- One large chapter on the conversion of widely-distributed military surplus equipment to amateur and other practical use
- New constructional data on beamtetrode amplifiers
- One chapter on determining the operational characteristics of all types of amplifiers
- New, simple FM exciter designs
- New data on transmitter control by improved methods
- New V-F-O design
- Simplified antenna tuning device and sending-wave meter
- The most extensive tube tables of any book not devoted entirely to such data.

MORE MATERIAL THAN EVER BEFORE, DURABLY CLOTHBOUND, GOLD-STAMPED, FOR ONLY

$3.00 per copy at your favorite dealer's in U.S.A. Mail orders, $3.25 postpaid in U.S.A.; foreign, $3.50 postpaid.

GET IT AT YOUR FAVORITE DEALER'S. If he cannot supply you, you may order direct from us by mail. DEALERS: "Technical" discounts allowed on this book when purchased by the radio, book, and news trades in quantities for resale.

Editors and Engineers LIMITED 1302 KENWOOD ROAD Santa Barbara CALIFORNIA

SPOT SURPLUS SPECIALS

DELIVERY GUARANTEED!

Our buyers attend all U. S. Gov't. surplus sales. We buy in quantities that enable us to offer you the best electronic equipment including hard-to-get radar and communications sets, tubes and parts -- at the lowest prices.

SEND FOR BULLETIN "M" FOR COMPLETE UP-TO-THE-MINUTE STOCK AND PRICE LISTS.

PACIFIC COAST DEALERS: Write for special prices.

New . . .
75 to 100 Mc. Receiver, $3.95
Carbon Mikes 25 cents each

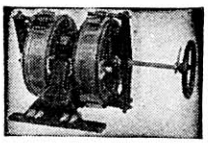
25% CASH WITH ALL ORDERS. MINIMUM ORDER $1.00

G. & M. EQUIPMENT CO., Inc.

4505 VAN NUYS BOULEVARD • VAN NUYS, CALIFORNIA • STATE 4-3233

INDUSTRIAL & ELECTRONIC POWER SUPPLY EQUIPMENT

TRANSFORMERS



T-103—Voltage regulator Transtat, American Transformer Co. Spec. 29145. Max. KVA output 11.5, 50/60 cyc. 0-115 V. 100 amps or 230 V. 50 amps. **$75.00** Net Wt. 134 lbs. Dim. 25" W x 16" D x 17½" H (Encl. 8" shaft ext.)

T-101—Plate Transformer, Amertran Spec. 29108. Primary 115 V. 60 cyc. 10.4 KVA. Secondary 17600 V. .520 amps. 35 KVA test..... **$65.00**

Net Wt. 500 lbs. Dim. 19" W x 15½" D x 41" H. O. A.



T-102—Filament Transformer. American Transformer Co. Spec. 29106, Type WS .050 KVA, 50/60 cyc. Single phase, 35 KVA test, 12 KV D.C. operating. Primary 115 V, secondary 5 V., 10 amps with integral standoff insulator and socket for No. 371, 872, etc. rectifier tubes..... **$12.50**

Net Wt. 15¾ lbs. Dim. 6½" W x 6" D x 12" H. O.A.

T-104—Voltage Regulator Transtat, American Transformer Co. Spec. 29144. 115 V. 60 cyc. Max. KVA .25 single phase, voltage range 103-126 volts, max. amps 2.17 (for filament voltage control)..... **$9.50**

Net Wt. 15 lbs. Dim. 5" W x 11" D x 7½" H. O.A.

CHOKE COIL

R-106—Amertran Disc. Type. Specification No. 29107. Line volts 15,000 V. D.C. Ripple frequency 120, 149 ohms resistance, .20 D.C. amps at 900 henrys 48% ripple, .52 amps D.C. at 25 henrys 48% ripple..... **$42.00**

Net Wt. 280 lbs. Dim. 17" W x 12" D x 31½" H. O.A.

CAPACITORS

C-107—G.E. Capacitor Cat. No. 14F59 or Westinghouse Inerteen, 1.0 mdf. 25,000 V. D.C.... **$36.00**

Net Wt. 65 lbs. Dim. 14½" W x 8½" D x 15" H. O.A.

C-132—Aerovox, 10 mfd. 600 volt, D.C. Oil filled **$1.00**

RELAY

RC-115—R.W. Cramer Co. Time Delay Relay, Type TD2 120S, 1 min. interval, 115 V. 60 cyc. Synchronous motor drive. Contact rating 10 amp. 115 V. single pole, normally open..... **$4.95**

METERS

M-144-5—R.W. Cramer Co. Running Time Meter —3". Type RT2H, 115 V. 60 cyc. Flush mounting..... **$5.95**

Net Wt. 1 lb.

M-141—Weston Model 476—3", 0-130 V. A.C. volt meter. flush type, calibrated for steel panel mounting..... **$4.95**

Net Wt. 1 lb.

M-140AB—Weston Model 476—3" A.C. Ammeter, 3 amp. full scale, calibrated 0-120 amps, flush mounting, with 40/1 current trans..... **$8.50**

Net Wt. 3 lbs.

M-146—Weston Model 476—3". Filament voltage indicator, 0-130 V. movement with 115 V. mark, flush mounting, calibrated for steel panel.... **$3.95**

Net Wt. 1 lb.

M-143AB—Weston Kilovoltmeter—3". Model 301, 20 KV @ 1000 ohms per volt, flush type, calibrated for steel panel mounting, with 20 meg. 20 KV Weston resistor complete with clips and standoff insulators..... **$18.00**

Net Wt. 4 lbs.

M-142—Weston Model 301—3". D.C. Milliammeter, 0-800 Ma., flush type. calibrated for steel panel mounting..... **$4.95**

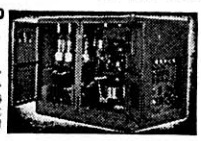
HEATERS

H-149—Chromolox strip heaters, 300 W., 115 V. (¾x1½x12")..... **$1.00**

MOTOR AND BLOWER

MB-156—Motor blower unit, Mfg. by Champion Blower Co. Cat. No. O-CE, direct connected, 4" inlet, 4" exhaust, 1/20 H.P., 115 V. 60 cyc. 1750 R.P.M. Capacitor motor **$21.50**

POWER SUPPLY



(RA-38) 115 V., 60 cyc. input, adjustable output 0-15,000 V. A.C. or D.C. @ 500 Mils. Shipping weight 2100 lbs..... **$200.00**

All merchandise in "as new" condition. Add approximately 20% to net weights for estimated shipping weights. Terms are 30% with order, balance C.O.D. All prices f.o.b. Los Angeles Warehouse.

Write for additional detailed information on any of the above items and for special quantity discounts.

1527 E. Seventh Street **EPCO** Los Angeles 21, California

Grooves Per Inch	Combined Width of Groove & Wall	Groove Width		Wall Width		Groove Depth			
						70° Stylus		90° Stylus	
		From	To	From	To	From	To	From	To
96	.0104	.0052	.0042	.0052	.0062	.0022	.0015	.0018	.0013
112	.0089	.0044	.0036	.0044	.0053	.0017	.0011	.0014	.0010
120	.0083	.0041	.0034	.0041	.0049	.0014	.0009	.0012	.0009
136	.0073	.0036	.0029	.0036	.0044	.0011	.....	.0010	.....
154	.0065	.0032	.0026	.0032	.0039	.0008	.....	.0008	.....

Groove dimensions.

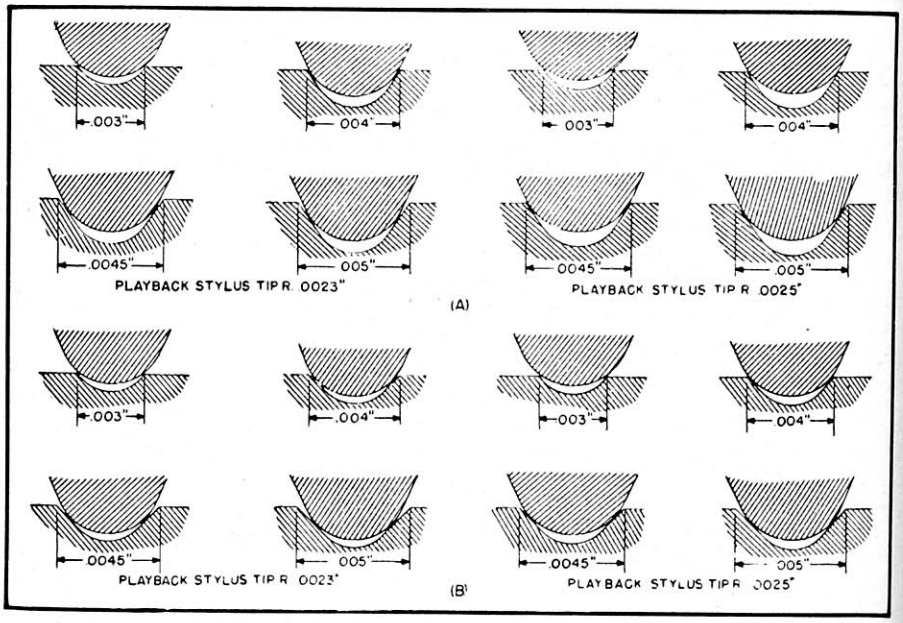
nect a high fidelity pickup through a calibrated attenuator to the input circuit of a high gain amplifier. Insert a high pass filter, such as the one contained in the MI-4917-A variable sound effects filter by *RCA*, in the circuit to eliminate all frequencies below approximately 200 c.p.s. The electrical location of the high pass filter is important. If two amplifiers are used connected in cascade, the ideal electrical location for the filter is between the amplifiers. Should it be necessary to use a single unit amplifier, the filter may be connected between the pickup and the amplifier input. Be sure to provide adequate shielding for the filter when using it in this position, however, since the hum pickup may be severe. Connect the amplifier output to a loudspeaker and a volume level indicating meter. Play the 1000 cycle tone band and then the noise sample. Adjust the output of the amplifier with a calibrated attenuator until a similar indication is obtained on the volume level indicating meter. The attenuator reading indicates directly the noise level in db. below reference level.

A convenient method for determining the presence of noise or scratch consists of connecting the cutter head as a reproducer. Insert the stylus to be checked in the cutter head and connect the leads from the head directly to the input terminals of the high gain amplifier which has a loudspeaker connected to its output terminals. Cut grooves in the record material, preferably near the outside diameter. Arrange the gain of the amplifier sufficiently to hear the sound made by the cutter. A steady hiss indicates a good grade of lacquer and sharp, properly adjusted stylus. Scratching, squealing, or tearing sounds indicate a dull or improperly adjusted stylus. Clicking or banging may indicate the presence of foreign particles in the lacquer.

Groove Spacing

The correct groove width is largely determined by the radius of the tip of the playback stylus, and by the signal level at which the recording is made. The groove should be wide enough so that the playback stylus tip contacts the side walls of the groove approximately 0.5 mil. below the surface of the record. Then ordinary light surface scratches will not be reproduced and will not add to the over-all record noise. Most lateral transcription pickups use styli which have tip radii between 2.3 and 2.5 mils. In order to obtain the proper fit, a groove width of 4.5 mils. or greater is recommended for cutting styli having either a 70 or 90 degree included angle. Fig. 6 illustrates the theoretical fit for various sizes of playback

Fig. 6. Theoretical seating of stylus in grooves of various widths. (A) Grooves cut with 70° stylus, (B) grooves cut with 90° stylus. (Tip radius .0017")



styli and groove widths. The tip radius of the cutting stylus should be 0.4 or 0.5 mils. less than that of the playback stylus so that the bottom of the record groove is cleared and does not form the major support for the reproducing tip.

To determine the pitch (number of grooves per inch) at which the record is to be cut, add to the groove width twice the maximum amplitude of expected stylus excursion (due to signal) plus an allowance for safety factor. Assume a normal stylus excursion of 0.626 mils. and a maximum of 10 db. above this or 1.98 mils. Twice this is 3.96 mils. plus a safety factor of 1.0 mil. added to a groove width of 4.5 mils. equals 9.46 mils., or about 109 grooves per inch. Low frequency peak amplitudes of 10 db. above normal are infrequent and it is questionable if two maximum stylus excursions will occur in adjacent grooves at such time and phase as to cut into each other. Therefore, some liberty can be taken and a slightly smaller pitch, about 7.35 mils., or 136 grooves per inch, is usually considered satisfactory when using a 70 degree cutting stylus.

The groove width should, however, never be less than 4.5 mils. when a playback stylus with a 2.3 or 2.5 mil. tip radius is used.

The tabulation (see page 152) shows the practical limits of groove and wall widths. All dimensions are in inches.

The author wishes to express his appreciation to *RCA* for many of the illustrations and the reference material used in this article.

(*To be continued*)

Cross-Modulation

(*Continued from page 56*)

in others to pickup in high-gain audio stages. All such cases were located within areas of extremely high field intensities, however, and represent a very small part of interference complaints. More common sources of cross-modulation are; (1) exposed power wiring, particularly if overhead mains are used; (2) poor electrical contact between sections of metal roofing, drain pipes, metal chimneys, electrical conduit, etc., and; (3) oxidization or poor contact in the antenna or ground system, guy wires, or nearby wiring. Often such objects as a galvanized clothesline may be the source of r.f. pickup and rectification without actually coming in contact with the antenna system.

Several years ago, WLW engineers investigated almost 100 cases of cross-modulation in Cincinnati. Of these cases, the sources of interference (in the order of their appearance) were; (1) loose connections, (2) complainant's receiver, (3) vent pipes, (4) image frequency, (5) downspout, (6) radiator pipe, (7) sink drain pipe, (8) antenna dragging on a metal roof. Of the total number of cases involved, over 10 per-cent were due to loose connections which allowed oxidization or rust to occur.

Methods of Elimination

The source of cross-modulation can best be located through the use of a portable battery receiver operated as a direction finder. The receiver

CHANGES IN STANDARD FREQUENCY BROADCAST

EFFECTIVE January 30, 1948, the technical broadcast services from radio station WWV of the National Bureau of Standards were somewhat modified and improved, according to an announcement by Dr. E. U. Condon, Director of the Bureau.

Each of the eight radio carrier frequencies 2.5, 5, 10, 15, 20, 25, 30 and 35 megacycles are now being broadcast continuously day and night. Standard audio frequencies of 440 and 4000 cycles per second are transmitted on the carriers 10, 15, 20, and 25. The 440 cycle frequency, which is the standard of musical pitch (A above middle C), is also being broadcast on 2.5 and 5 megacycles. The accuracy of each of the transmitted radio and audio frequencies is better than one part in 50 million.

The attention of all users of the National Bureau of Standards time announcements is particularly called to the following change: Time announcements in International Morse Code, accurately synchronized with basic U. S. Naval Observatory time, have been advanced one minute with respect to the old announcement scheme. With the new system the audio frequencies are interrupted at precisely one minute *before* each hour and at each succeeding five-minute period. They are resumed precisely on the hour and each five minutes thereafter.

Under the old system, the time signals were interrupted for a minute on the hour and on each succeeding five minutes, while under the new scheme interruptions are for a minute precisely on the 59th minute, on 4 minutes past the hour, 9 minutes past the hour, etc., and resumed precisely on the hour and each five minutes thereafter. The exact moment to which the time refers is the moment of interruption of the audio frequencies of 440 and 4000 cycles per second. The audio frequencies will continue to be interrupted for one minute to allow for the time announcement, for station identification by voice at the hour and half hour, and to afford an interval for checking radio frequency measurements free from the presence of audio transmissions.

Station WWV provides six important technical broadcast services to the nation and five to the world, 24 hours a day. These are; (1) standard radio frequencies, (2) time announcements, (3) standard time intervals, (4) standard audio frequencies, (5) standard musical pitch, (6) radio propagation disturbance warning notices.

A detailed announcement of WWV broadcast services, LC886, will be provided upon request from the National Bureau of Standards, Washington 25, D. C.

-30-

PEAK SURPLUS SPECIALS

G.E. 2" SCOPE

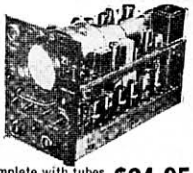


This compact unit only 4½x 2½x8¾" ideal for modulation indicator etc., has focus intensity and reticle brilliance controls—Uses 2AP1, CRT and 9006 rectifier. We supply complete instructions with each scope. Rectifier built in —need only transformer delivering 350-400 v. 6.3, volts for operation. Very simple changes. Comes with 9006 but less 2AP1. Only..... **$4.95**
2AP1.....$2.50



S.C. TEST SET (1-114)
In portable wood case 6"x 6"x10", including cover not shown, with Weston 0-150 v. AC. Meter has 2 switching ckts and comes complete with test and line cables. A Buy At Only..... **$3.95**
Same with other make meter.....$3.25

APN 4, 5" SCOPE INDICATOR (25 tubes)



Makes an ideal basis for 5" scope. Also can be converted into Panadaptor with marker pips at 100 KC - 20 KC - 2 KC., for measuring drift and width of F.M. Has electronic switch for observing 2 frequencies simultaneously. Unit contains an accurate 100 KC crystal. Tube complement: (1) 5CP1 (3) 6SL7 (14) 6SN7 (6) 6H6 (1) 6SJ7. Complete with tubes and 100 KC crystal. Marvelous buy at..... **$24.95**

R.C.A. POWER TRANSFORMER
770 V.C.T. 100 ma., 6.3 volts—2.5 amp. 5 volts—2 amps—3½"x 4" x 4½".....$2.75

BRUTE FORCE
A heavy duty Western Electric Filter Choke 4.3 henry 620 mills 42 ohms DC resistance 4⅞x5⅜x5⅜ (Ceramic Insulators on top). A Peak Bargain at..... $4.95

BC454B—3-6 MC Superhet. Complete with 6 tubes.....$4.95

FILTER CHOKE—8 henry 160 mills—140 ohm D.C. resistance. $1.39 ea.....2 for $2.50

METERS (Standard Brands)

2" 0-5 ma (amp scale)	$1.95
2" 0-1.2 ma	2.49
2" 0-1 amp R.F. (internal thermo)	3.49
2" 150-0-150 microamps	3.49
2" 0-1 ma (volt scale)	2.95
2" 0-50 microamps (square)	7.50
3" 500-0-500 microamps. (Blank scale)	3.95
3" 0-1 ma	4.50
3" 0-2 ma D.C.	3.95
3" 0-20 ma D.C.	3.95
3" G.E. 0-15 ma D.C. (square)	3.95
3" 0-150 volts A.C.	3.95
4" 1-0-1 ma D.C. (Blank scale)	3.95

Voltage Regulated Power Supply—input 110 v. 60 cy. Delivers 150 v. DC—Well filtered (3 chokes) uses VR 150 and 6X5. Has extra 6.3 v. winding. Swell for eco's, freq. meters, etc., 16x3⅛x5 with tubes. Only.....$6.85

OIL CONDENSERS

2 mfd 600 vdc	$0.39	3 mfd 3000 vdc	$3.95
4 mfd 600 vdc	.59	1 mfd 4000 vdc	3.75
3/3 mfd 600 vdc	.79	1 mfd 5000 vdc	4.50
4/4/4 mfd 600 vdc	.95	.1 mfd 7500 vdc	1.95
14 mfd 600 vdc	1.35	.1/.1 mfd 7500 vdc	2.45
2 mfd 1000 vdc	.79	.01/.01 12 KV dc	5.75
4 mfd 1000 vdc	.95	.005/.01 12 KV dc	5.50
2 mfd 1500 vdc	1.25	.65 mfd 12500 vdc	12.95
1 mfd 2000 vdc	1.15	.75/.375 mfd (dual) 8/16 KV dc	14.95

GIZMOS
—Thousands of good parts here in quantities too limited to advertise. If you send $2.50 for our "Gizmo Package" we promise you won't regret it.

MISCELLANEOUS SPECIALS

2-11 mmf Butterfly Cond.	$0.59
Millen Var. 150 mmf .077 GAP	1.69
CD 16 mfd 450 v.	.59
Kit 50 mica Condx	2.39
CD .002 Mica 7500v. T.	.69
Kit of 5 relays	.99

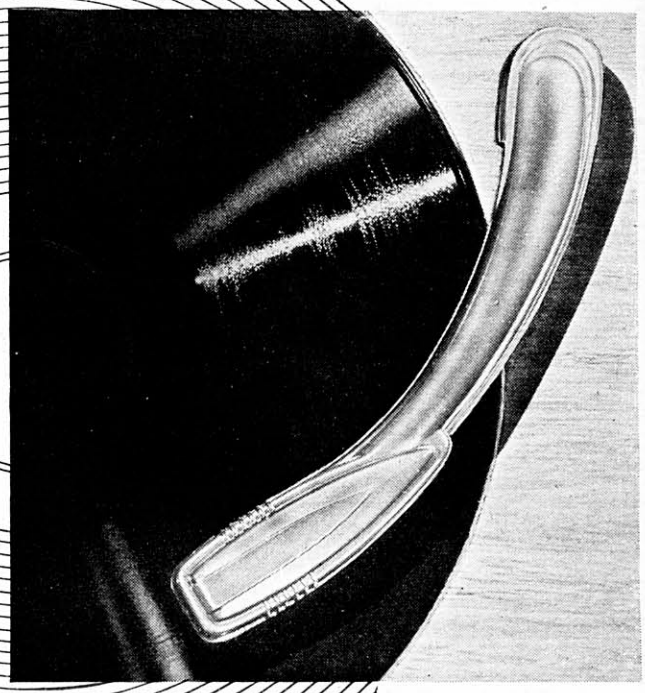
If not rated, 25% with order, balance C.O.D.

PEAK ELECTRONICS CO.
188 WASHINGTON ST., DEPT. MR
NEW YORK 7, N. Y.

The RECORDING and REPRODUCTION of SOUND

By OLIVER READ
Editor, RADIO NEWS

Part 14. A discussion of phono pickup tracking error, groove skating, and record wear.



Modern offset type tone arm reduces record wear.

ENGINEERS, several years ago, realized that in order to obtain the utmost fidelity and minimum record wear, some means should be provided to offset the tendency of the pickup tone arm to "ride up" on a groove during reproduction. Many theories have been advanced regarding the effects of "tracking error," with the result that the layman is often confused when attempting to understand the fundamental rules that govern the final results.

So-called straight arm phono pickups were commonly used up until a few years ago. Little thought was given to the effects of proper "tracking" and "groove skating." The distortion caused by improperly designed tone arms meant but little as few instruments were capable of attaining high fidelity. The old conventional tone arm was designed somewhat as illustrated in Fig. 1. Note that the tone arm swings in an arc (*A-B*) as indicated. With this type of tone arm there is only one point on the record, that near the center of swing, where the needle or reproducing stylus will be seated correctly within the groove. At any other position of the arm travel, the stylus will either be forced to the right or to the left of that position. In other words, the pickup element or cartridge will not be at right angles to the direction of travel.

This tracking error becomes greater as the two extremes are reached by the needle as the angles become greater with a resulting increase in distortion and record wear. At all positions except that at which the needle appears at right angles to the groove there will be a tendency for the needle to ride up on the walls of the groove. This becomes rather serious as the outside or inside grooves are reached as the action becomes more exaggerated.

Groove Skating

Groove skating results from improper tracking. Under such conditions it is impossible for the needle to reproduce properly as a great part of the applied needle pressure is from the sides or "walls" of the groove. This has a tendency to actually steer the needle away from its normal resting condition (Fig. 1C). There can be only one pivot point for the tone arm. Obviously then, the only remedy to offset the tendency of the needle to ride up on the walls of the groove is to change the straight arm design to one which will "offset" the angle thus enabling the needle to approach a closer correct angle with relationship to the groove.

Fig. 2 illustrates several offset heads of improved design. Further improvement is obtained when the point of the reproducing needle contact is swung through a lower arc, one farther from the normal hub line or center hole of the record, as illustrated in Fig. 3.

We now find that the new arc starts below *D* and the needle travels approximately ⅜" below the arc shown in Fig. 1. Three possible positions for the needle are illustrated; one at the outside groove, another at point *F*, and the other at the inside groove of the record. Note that we approach a right angle to the groove as the arm travels throughout the record and a better average is maintained due to the offset position of the head.

Considerable record wear will result if the foregoing considerations are not met. If a needle, especially a sharp one used on commercial pressings, is allowed to ride up on the sides or walls of the groove, it can only result in continuous wear on the record material at the point of needle contact. Sound modulations are cut into the sides of *each* groove, not at only one side. Naturally then, we must take the required steps and make certain that the needle is allowed to engage both walls at the same time with even pressure or, more accurately, to see that the needle is "seated" properly.

The effects of improper tracking become even more acute with transcription and home recording blanks as the record material is considerably softer and the walls of the groove are more subject to mechanical distortion than are commercial hard shellac pressings.

An improvement can be made in the playback setup by employing pickups of the lightweight class—those

having a needle pressure of from ¼ ounce to 2 ounces. On the other hand, too little pressure is not recommended as this too can actually increase the wear on the groove walls. The pickup, therefore, must have enough point pressure to permit the needle to "seat" in the bottom of the groove and to be able to guide the complete pickup arm across the record in a horizontal plane.

The use of sapphire playback styli (needles) is recommended for all types of soft disc materials, due to the ability of the stylus to maintain a correct shape for hundreds of playings. While these are more expensive initially, the cost is offset by the saving in replacements.

As an analogy, we might point out that in early machines, such as the cylindrical record phonographs and other dictating machines, the locus of the reproducing stylus is in the straight line with perfect tangency to the groove at every point on the record. In the case of reproduction by means of the conventional pivoted tone arm, the locus (the path) of the needle point is the arc of a circle. Perfect tangency to the groove is possible at only one or two points on the record, as previously mentioned. Tracking error is the result of a pivoted tone arm and is obviously an inverse function of the length of the tone arm.

Tone Arm Length

Fig. 4 illustrates a graphical method for determining tone arm length developed by Mr. Roy Dally.[1] To arrive at the proper over-all length of a tone arm, and the included angle of offset, any shape or design of tone arm may be laid out over the backbone as long as the essential dimensions are not disturbed.

First lay out, full size, the outside groove of a twelve inch record. This averages 11½" in diameter. Then lay out the inside groove of a 10" record, which is about 4". The only factor that must be known beforehand is the distance from the center of the record to the lateral bearing which is usually the center of the mounting hole. This is an arbitrary distance and depends upon the space available. Let us use, for illustration, a dimension of 7". Locate this point with reference to the record center. Now construct a center groove which lies equidistant between the outer and inner grooves. Lay in line *A-A* which is a tangent to the center groove. Construct the arc *B-B* whose radius is the distance from the mounting hole to the record center. Using this same radius, locate the compass needle on tangent line *A-A* so that the compass point intersects the tangent point *X* in the center groove.

Construct an arc *C-C* so that both ends intersect *B-B*. Draw the straight line *D-D* which passes through the arc

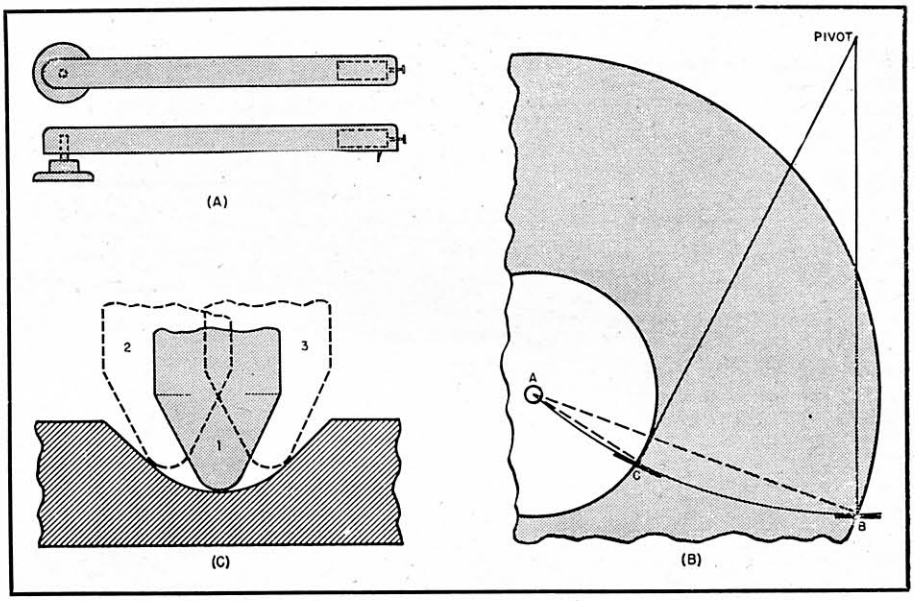


Fig. 1. (A) Straight tone arm. (B) How not to mount a tone arm. (C) Variations of groove skating.

intersections and line *E-E*. The point *Y* then represents the needle point and the distance from *Y* to the mounting hole center becomes $7\frac{11}{16}$". The $\frac{11}{16}$" is the distance the needle point must be beyond the center of the record when the pickup is mounted in order to insure proper tracking.

Next construct the arc *F-F* whose radius is $11\frac{11}{16}$". Draw tangents *G-G*, *H-H*, and *I-I*, using a right triangle between the record center and intersection points of grooves and tangent lines. Then draw lines from the mounting hole center to the same points. The three included angles shown indicate the degree of offset necessary to have perfect tracking at those respective grooves.

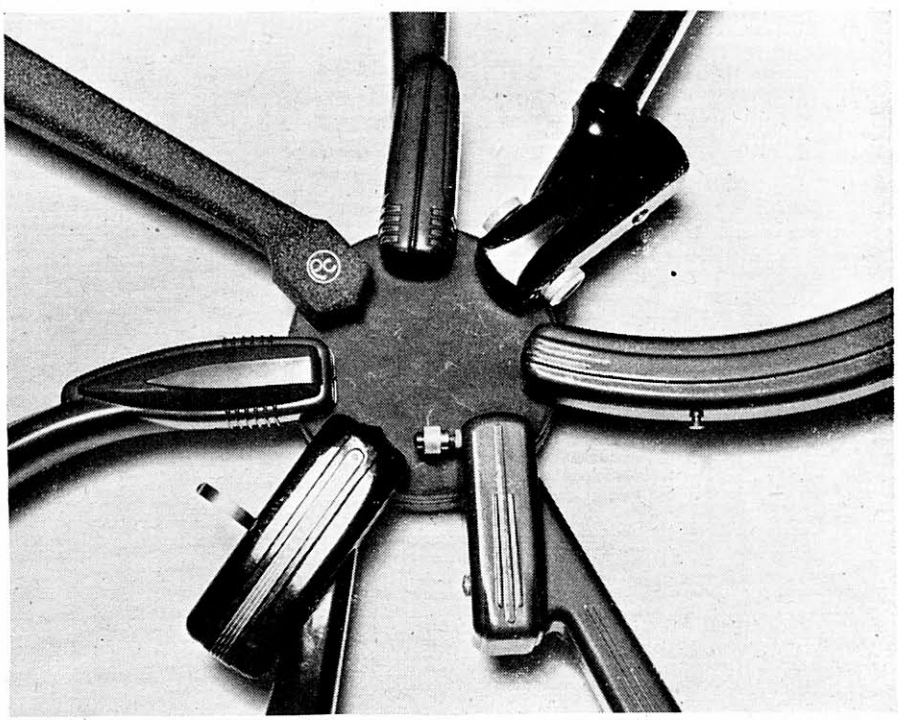
An average included angle would be about 27 degrees which would permit an error on one side of 1 degree and on the other side 1½ degrees. This gives the total tracking error of 2½ degrees.

Styli and Record Wear

The perfect reproducing needle or stylus would be one which would maintain its shape throughout many thousands of playings. Regular commercial records, as purchased in music and radio stores, use a shellac base rather than the soft lacquer material used to coat the surfaces of home and transcription discs. The purpose of the shellac, other than that of a bond-

(*Continued on page* 116)

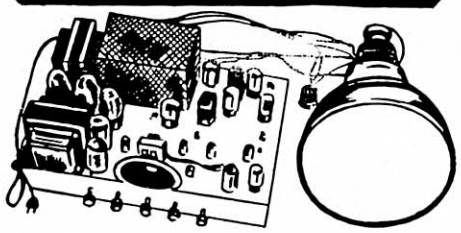
Fig. 2. Note the variation of offset angles on these modern tone arms.



1. *Dally, Roy, Consulting Eng., The Electrovox Co., Inc.: "Tone Arm Design," Radio, July, 1944.*

AMAZING NEW LOW PRICES!

7" and 10" TV "TELEKITS"



Never before have television kits manufactured by one of the country's leading firms been offered at such a low price! They're easy to assemble . . . with guaranteed performance. Each kit complete with instruction books, photos and diagrams. Ideal for beginner or experienced radio technician.

SEVEN-INCH KIT WITH 13-CHANNEL TUNER **59.50** LessTubes & Cabinet

Number 7 is the perfect set for the television beginner, and brings better picture reception than commercial receivers of its size. The new 13-Channel Tuner is prewired and factory aligned for the entire Television spectrum of 13 channels. The kit builder merely installs this unit into the Telekit chassis and makes 3 connections. Contains R. F. Stage, Oscillator and Mixer. High voltage transformer insures brilliant, sharply focussed pictures. Sound reception is high quality F.M.

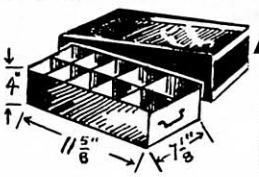
Tube Kit Including 16 Tubes Plus 7" Picture Tube 39.50 . . . . . Cabinet 21.00

TEN-INCH KIT WITH 13-CHANNEL TUNER **99.50** LessTubes & Cabinet

• Incorporation of the Telekit Thirteen Channel Tuner • Uses the modern flyback transformer method of securing the 10,000 volt second anode supply for 10BP4 Picture Tube • Magnetic deflection and focusing • Ion trap electromagnet prevents burning of screen • Uses two complete low voltage power supplies which prevent interaction between picture and sweep circuits • Features the T.T.I. sync interlock circuits which insures stability under low signal strength and noisy conditions.

Tube Kit Including 18 Tubes Plus 10" Picture Tube 59.95 . . . . Cabinet 23.50

STEEL PARTS CABINET **3.67**



Heavy gauge steel. 10 partitions. Ideal for resistors, condensers and other small parts. Buy several—they can be stacked upon one another.

Radio Electric SERVICE CO. OF PENNA., INC.

7TH AND ARCH STREETS, PHILA. 6, PENNA.
Branches 5930 Market St. and 3145 N. Broad St. in Phila. Also in Wilmington, Del., Easton, Pa., Allentown, Pa., Camden, N. J.

Recording of Sound

(*Continued from page 73*)

ing material, is to make possible the inclusion of an abrasive which is added to the compound for purposes of sharpening a steel playback stylus.

The conventional sharply pointed steel reproducing needle (Fig. 5B) is familiar. When initially employed on a record, considerable hiss is present due to the sharp needle point of the stylus engaging the bottom of the groove of the record. Due to the speed and grinding action of the revolving record there will be a gradual wearing of the needle point. While initial surface noise reduces somewhat during playing, distortion will result as the reproducing stylus becomes worn. The abrasive material in the record will grind off the sharp point of the needle and the stylus will assume a rounded and somewhat distorted point. If permitted to run for any length of time, the walls of the groove will be torn and worn from improper seating, hence the necessity for changing needles, as is done with the conventional phonograph.

With the advent of *permanent* point types (sapphire, diamond, etc.) of stylus tips, this condition has been somewhat alleviated. The stylus tip is not worn due to its ability to maintain its initial shape for many thousands of playings. Such styli are less hazardous to the life of the record. Normally, looking directly from the end cross-section of a groove, we find

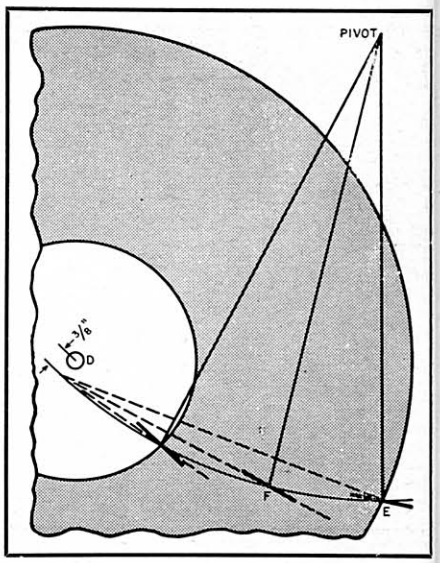


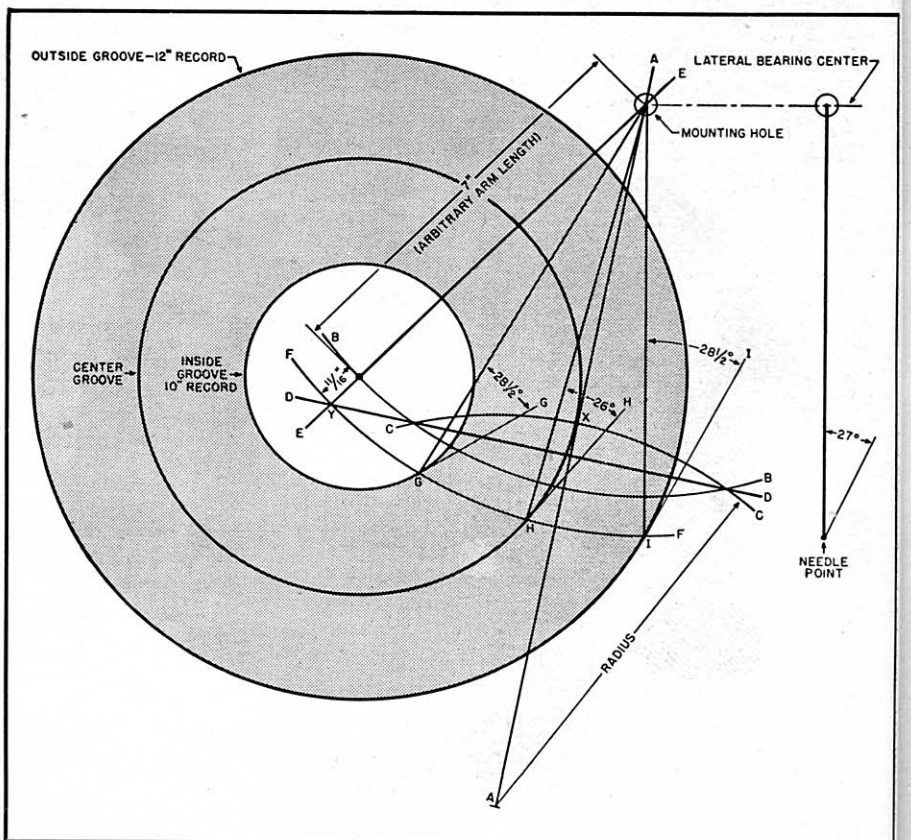
Fig. 3. Reproducing needle swings in arc below hub line.

that it is V-shaped. Obviously a sharp pointed needle, when used on a new record, engages only the bottom of this groove. Inasmuch as modulation is on the *walls* of the groove, there is no proper seating or contact with the walls of the groove for many revolutions of the disc.

Pinching Effect

A flat tool-like chisel point is used, as explained in Part 13, which cuts the groove in a revolving recording blank. The face of the *cutting stylus* cuts a groove of even width providing no sound is impressed on the cutter.

Fig. 4. Method for determining correct tone arm length and included angle of offset.





THE NEW NC-108
FM TUNER-RECEIVER

Now...National offers an 88-108 Mc. band FM tuner-receiver designed to meet the most exacting demands of high-fidelity enthusiasts! Flat from 50 to 18,000 cps, ± 2 db, the new NC-108 may be connected to your amplifier or the phono input of your radio. Built-in speaker, audio output stage and tone control also permit use as separate monitoring receiver. Built to National's famous standards of quality, the NC-108 is worthy of the finest in amplifiers and speakers. Nine tubes plus rectifier and tuning eye.

$99.50
Amateur Net

For complete specifications see the National dealer listed in the classified section of your 'phone book, or write direct to

National
© EST. 1914
NATIONAL COMPANY, Inc.
MALDEN, MASSACHUSETTS

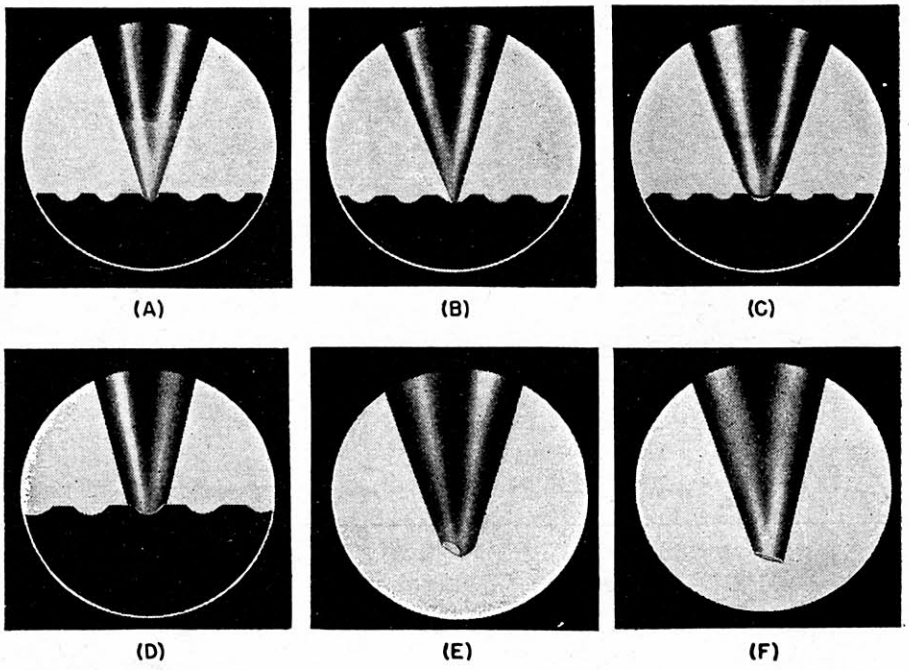


Fig. 5. Microphotographs of reproducing styli showing several conditions as met in everyday practice by the professional studio and by the home recordist. (A) a correctly seated stylus in a properly cut groove. (B) How a sharp point on the stylus can cut into the soft surface material. (C) Indicates the condition when a too rounded stylus rests on the walls of the groove. (D) A worn stylus ground to fit into the groove. (E) A chipped or defective stylus point. (F) Indicates a worn out or damaged needle point.

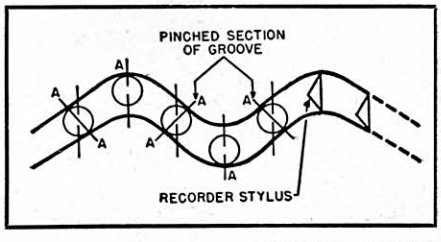
However, when modulation takes place the actual width of the groove varies with frequency, disc diameter, etc., as illustrated in Fig. 6.

A *reproducing stylus* has a rounded point, therefore, it is almost impossible for this point to seat properly in the modulated groove. The illustration, Fig. 6, serves to show the effect. Note, for example, that the width of the recording stylus at the maximum swing results in a certain dimension in the groove. Comparing this to the point of a reproducing stylus, we find that the tendency is for the point to ride out on the crest, or maximum modulation point, of that particular crest. Hence, sound vibrations are impressed on the needle at the farthest point of inertia. Actually, the point skids from side to side in the wider portions of the groove. Another possible cause of distortion, when the recording has been made with a chisel-shaped cutter and reproduced with a round point, occurs when the needle rounds a curve, as illustrated in Fig. 6.

There is no "cure-all" for the elimination of record wear and distortion. Suffice to say that the chief remedies are as follows: A perfectly level turntable free from mechanical vibration, a pickup having a tone arm with an offset head which permits a minimum degree of tracking error, and properly designed reproducing styli. By paying particular attention to these requirements, the recordists and music lovers may be assured that they have taken the necessary steps for the ultimate in reproduction.

One other important factor having an effect upon fidelity and its relation to record wear and distortion is in improved design of the pickup cartridge and reproducing stylus. By employing a "knee action" as illustrated in Fig. 7 we can eliminate somewhat the pinching effect. A widening and narrowing of a groove results from a spade-like cutting point. The driving force of the record causes the stylus to move in a vertical direction and occurs at a frequency which is double that of the lateral motion of the groove. If this vertical movement of the stylus produces an electrical output (as it does in many common crystal pickups now on the market), the result is an appreciable amount of second harmonic distortion in the reproduced sound. At the same time, the pinch effect produces a mechanical reaction on the record and stylus, as previously explained. The magnitude of the pinch effect is inversely proportional to the distance from the center of the record. It may be seen by inspecting worn records that the greatest wear occurs near the center of the record. The pinch effect is undoubtedly responsible for greatly accelerating this record wear. In most of the newer pickups now used the mass of the moving parts is small enough so that the vertical inertia re-

Fig. 6. How rounded-point needle (A-A) skids like a toboggan in modulated groove.



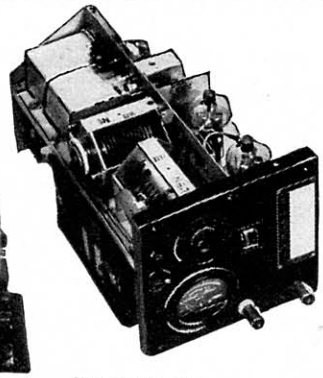
RU-16/GF-11

Introducing That Famous
TRANSMITTER RECEIVER COMBINATION!

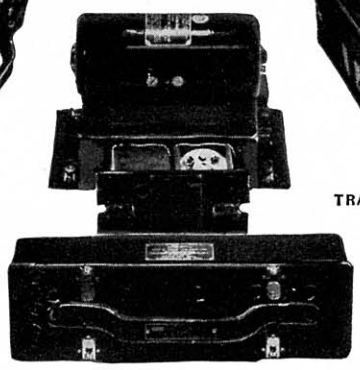
TRANSMITTER
2,000 KC—9,000 KC
RECEIVER
200 KC—13,575 KC



RECEIVER



TRANSMITTER



COIL DRAWER

A complete station, VFO operated, for
$29.50
only
Brand new as of the manufacturer

★ Output on phone 15 W, much more on CW.
★ Band changes by single plug-in drawer; 4 included with transmitter, 10 with receiver.
★ Simple conversion for output also on 14 Mc, 21 Mc, 28 Mc!
★ Dynamotor input 12 VDC, output 435 V @ 163 ma. continuous duty.
★ Transmitter tube complement 89-89-837's in PP.
★ Includes all accessories, filter, instruction book, remote tuning, control boxes, plugs, spare tubes, shock mounts, everything.

We can't describe the superb appearance and design, so write for our detailed description and modification suggestions of a terrific double conversion receiver, and a beauty of a VFO transmitter that has no equal. You will hear plenty on the ham bands about this neat combination. Shipped in original crate 32 x 21 x 22 wt. 120 lbs.

25% deposit with order

SURPLUS RADIO, INC.
30 MUNSON ST.,
PORT WASHINGTON, N. Y.

Studio Quality
AMPLIFIERS
WITH CUSTOM-BUILT FEATURES

Designers and Manufacturers of Broadcast Speech Equipment, School Sound Systems and Recording Equipment.



Designed and Fabricated by the Manufacturers of High Quality Sound and Recording Equipment for the Motion Picture Industry.

Bardwell & McAlister's new line of Commercial Amplifiers answers the great demand of sound engineers for commercial amplifiers embodying the principles used in "custom-built" units which have been successful in the sound equipment of the motion picture industry. These principles result in high fidelity reproduction at any setting of volume controls up to full rated output with less than 4% distortion, versatility of application, ease of operation and the longer life found only in Bardwell & McAlister Studio Quality Amplification Systems. Manufactured by Union Craftsmen and fully licensed.

Write for our sound equipment catalog and technical bulletins. Dealer inquiries invited.



13

A BM INC PRODUCT

ELECTRONIC DIVISION
BARDWELL & McALISTER, INC.
BOX 1310, HOLLYWOOD 28, CALIFORNIA

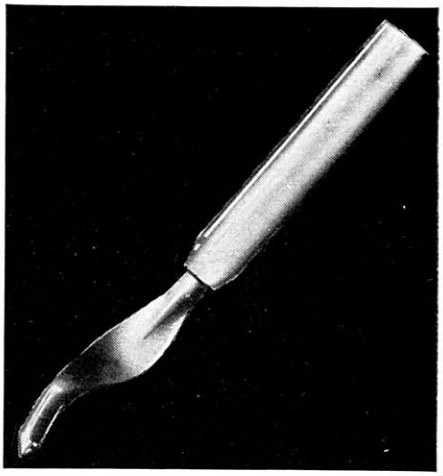


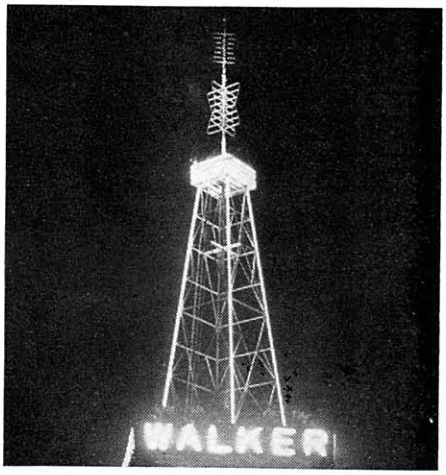
Fig. 7. Playback needle with "knee-action" feature.

action on the stylus and record due to the pinch effect is of negligible magnitude and does not contribute appreciably to record wear.

The "needle talk" is greatly reduced by employing such design. This is particularly true at the lower frequencies because of the reduced vertical reaction on the record. In relieving this reaction, the stylus and armature move vertically as a unit up to a frequency of between 500 and 800 c.p.s. rotating about a horizontal transverse axis. As the frequency increases, this axis moves closer to the armature until, at very high frequencies, the axis of rotation passes through the armature.

Record life has thus been increased considerably by careful design of pick-ups and their associated reproducing styli.

(To be continued)



Night view of station KDYL's super turnstile or "bat wing" antenna used for both experimental television and FM transmission. The antenna is mounted on top of Salt Lake City's highest office structure, a 20-story bank building in the business district, and towers 330 feet in the air giving coverage of the Greater Salt Lake Valley. KDYL's experimental telecasts from St. Louis to the Pacific Coast over station W6XIS, were started last month. The station which operates on channel 2 is powered at 400 watts visual and 200 watts aural. Commercial operation is expected before the end of 1948 on this circuit.

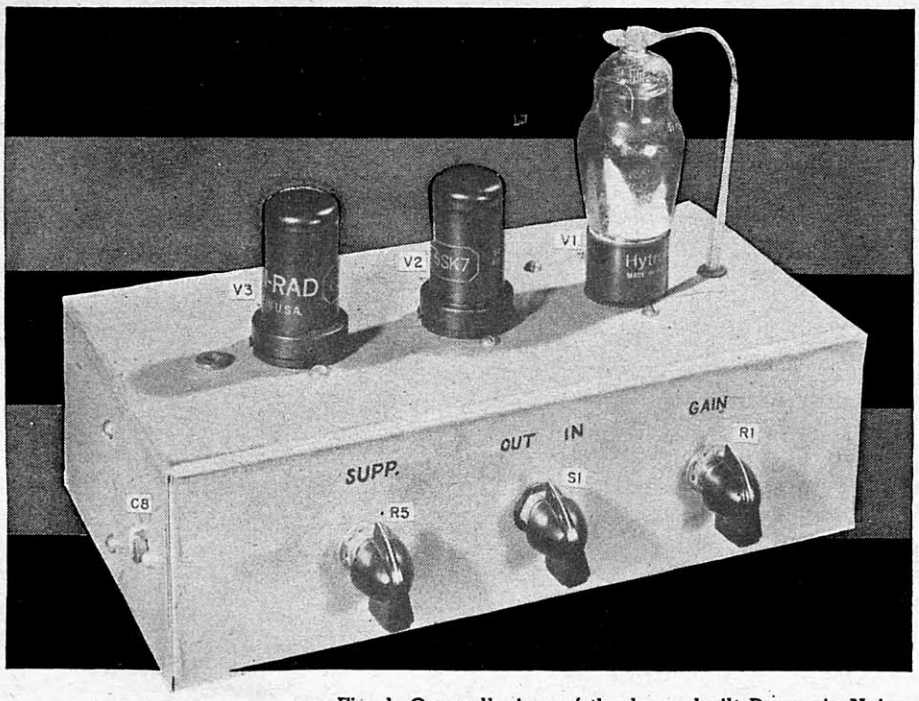


Fig. 1. Over-all view of the home-built Dynamic Noise Suppressor which uses readily available components.

The RECORDING and REPRODUCTION of SOUND

By OLIVER READ
Editor, RADIO NEWS

Part 15. Theory, design, and construction of a Dynamic Noise Suppressor that uses standard parts.

A PROPERLY designed Dynamic Noise Suppressor is an extremely worthwhile adjunct to any high quality playback system. On the other hand, an improperly adjusted suppressor is worthless and will cause many a headache to the soundman. Therefore, one should not attempt to build a unit unless he has access to an accurate audio oscillator and an oscilloscope. In addition the builder will need to borrow a second audio oscillator, for initial adjustments.

The suppressor to be described has been stripped to a minimum of components and tubes. It is capable of doing an excellent job and may be built successfully by any well-informed radio technician. Construction should not, however, be attempted by the tyro.

Various types of amplifiers require special changes in component parts values for best results. Therefore, this suppressor should be inserted into audio channels having similar characteristics to that of the record-reproduce amplifier shown on page 56 of the January 1948 issue of RADIO NEWS.

Originally this amplifier was to contain the integral Dynamic Noise Suppressor circuit. Extended research, however, indicated the desirability of building it on a separate chassis so that if any further changes were needed, these could be made without "messing up" the amplifier. In addition, it was discovered that there was a tendency for the two chokes, CH^1 and CH^2 (Fig. 2) to pick up hum from within the amplifier. This hum has now been eliminated by employing a separate chassis.

All of the components fit nicely into a standard chassis measuring 9½"x5"x 3". Two automobile radio type connectors are provided on the chassis for the two shielded leads connecting the suppressor into the amplifier. The output voltage from C^6 (Fig. 4, page 56, January 1948 RADIO NEWS) connects to the input of the Dynamic Noise Suppressor. The output of the D.N.S. connects to the input of R^{11}. In other words, the D.N.S. is inserted at the junction between C^6 and R^{11} of the record-reproduce amplifier.

Necessary filament and plate voltage for the D.N.S. may be taken from the power supply of the amplifier. It is recommended that the +250 volts d.c. be taken from the screen of the 6V6 through an additional dropping resistor of 10,000 ohms and an added filter condenser of 16 μfd. Likewise, the filament voltage may be taken from the filament winding supplying the 6V6.

This simplified circuit of the Dynamic Noise Suppressor uses a 6B8G to provide the necessary voltage amplification so that sufficient drive will be available to the d.c. control circuits for 6SK7 reactance tubes. The desirability of the 6SK7 as opposed to a sharp cut-off pentode such as a 6SJ7 is associated with smooth and continuously variable action of the "gate" circuits. A sharp cut-off tube tends to produce an undesirable "on-off" effect while the transconductance of the 6SK7 may be varied over a wide range. The diodes in the 6B8G envelope are used to rectify the control voltage.

Since it is desirable to provide a control voltage for the high frequency reactance tube derived from the upper fundamentals, and a derivative of the harmonics of low frequencies to drive the low frequency reactance tube, suitable *RC* filter networks are inserted ahead of the diodes. The reason for making the control voltages selective with regard to frequency is to avoid the possibility of the noise (either low frequency rumbles or high frequency needle scratch) from developing sufficient voltage to open the gates.

The rectified control voltage is further filtered by the networks following the diodes and the resultant d.c. applied to the grids of the reactance tubes. The speed with which the gates will open is largely a matter of time constants of these networks. The closing speed is also controlled by this factor but is further affected by the maximum voltage to which the condensers have been charged. In other words, if x volts are required to open the gates fully and the signal is sufficiently large to develop $2x$ volts across the filter condensers, they must discharge down to x volts before the gates will begin to close. Thus the closing time is longer for large signals than for medium signals. In general this is desirable because large signals usually require a longer reverberation time for realistic reproduction. In the

more elaborate versions of the Dynamic Noise Suppressor these effects may be controlled more accurately by the use of a separate amplification stage for the d.c. control voltage and arrangements to limit the maximum control voltage that may be developed. However, this is not so important in the more limited range devices as it is in those designed to handle very wide frequency response ranges.

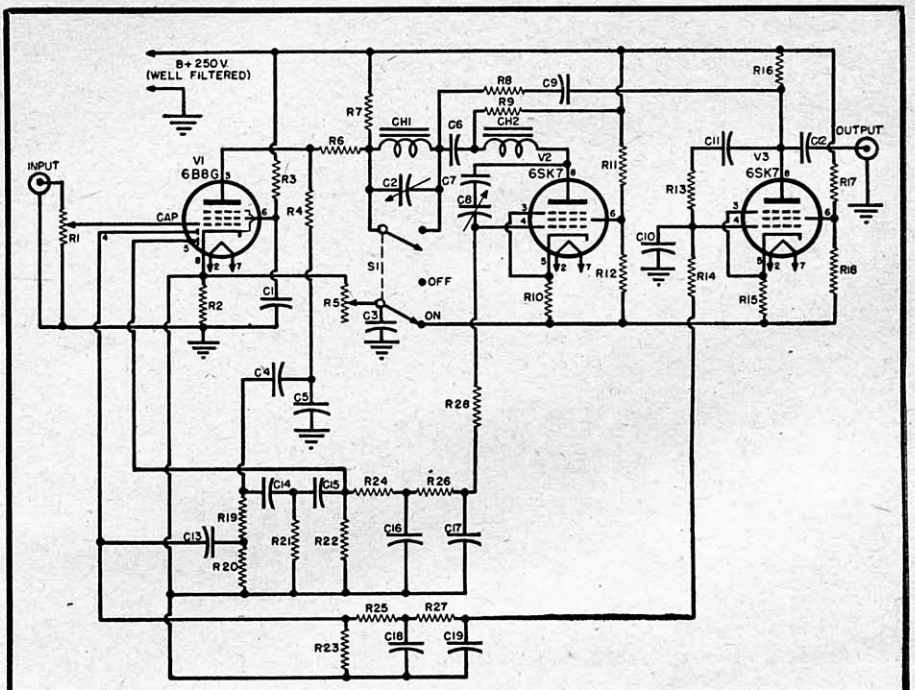
The use of the diodes in the 6B8G for rectifying the control voltage requires that the cathode of this tube be used as the effective ground return for all other tubes.

The resistors R^6 and R^7 are selected to divide the voltage properly so that an adequate drive will be available for the control circuits and also to produce a proper input impedance for the gate circuits. The "roll-off" ahead of the sharp dip in the high frequency gate circuit is a function of the value of these resistors. The series filter consisting of CH^1 and C^2 in parallel is tuned to resonate at 10 kc. It serves the dual purpose of holding down the very high frequencies when the gates are closed and the rise above resonance in the reactance tube circuit is appreciable in a region of considerable noise, and also provides the proper impedance for the shunt reactance tube tuned circuit to "work on." Since the condenser is capable of tuning this inductance over a broad range its inductance value is not extremely critical, but it is important that it be of high "Q" design.

The inductance CH^2 is also in a tuned circuit controlled by the condenser C^8 and its value is not critical although the "Q" is obviously important. C^7 is simply a blocking condenser to keep the plate voltage off the tuning condenser.

Analysis of these circuits will involve viewing the tube as a condenser in a tuned circuit. A simple method of understanding the results obtained is to think of it as a feedback device. A portion of the feedback voltage is applied to the grid of V^2 through condenser C^8. The voltage appearing on this grid is in phase with the signal on the plate. The grid voltage causes a corresponding change in plate current which produces a change in plate voltage that is 180 degrees out of phase with the input signal to the plate and is therefore degenerative.

The signal appearing in the grid circuit will vary with frequency in accordance with the characteristics of the network consisting of C^8 and R^{28}. The magnitude of the degenerative signal produced depends upon the transconductance of V^2. Under static conditions this will vary with the cathode bias developed across R^{10} and R^5 as well as the screen voltage. The screen voltage is held relatively constant by the divider



R_1—500,000 ohm pot.
R_2—1,000 ohm, ½ w. res.
R_3, R_9, R_{16}, R_{21}, R_{24}—470,000 ohm, ½ w. res.
R_4, R_6, R_{11}, R_{17}—100,000 ohm, ½ w. res.
R_5—500 ohm rheostat
R_7—33,000 ohm, ½ w. res.
R_8, R_{28}—47,000 ohm, ½ w. res.
R_{10}, R_{15}—330 ohm, ½ w. res.
R_{12}, R_{18}—5,600 ohm, ½ w. res.
R_{13}, R_{20}, R_{25}, R_{26}, R_{27}—1 megohm, ½ w. res.
R_{14}, R_{19}—220,000 ohm, ½ w. res.
R_{22}—4.7 megohm, ½ w. res.
R_{23}—2.2 megohm, ½ w. res.
C_1—.1 mfd., 400 v. cond.
C_2—50 mmfd., var. air cond.
C_3—100 mmfd., 50 v. elec. cond.
C_4—.001 mfd., 200 v. cond.
C_5, C_{14}—500 mmfd., mica cond.
C_6, C_9, C_{12}—.01 mfd., 400 v. cond.
C_7, C_{10}—.002 mfd., 400 v. cond.
C_8—100 mmfd., var. air cond.
C_{11}, C_{17}—.005 mfd., 400 v. cond.
C_{13}, C_{18}, C_{19}—.05 mfd., 200 v. cond.
C_{15}, C_{16}—.01 mfd., 200 v. cond.
S_1—D.p.d.t. switch
CH_1, CH_2—2 hy. choke (Allied X60-801)
2—6SK7 tubes
1—6B8G tube

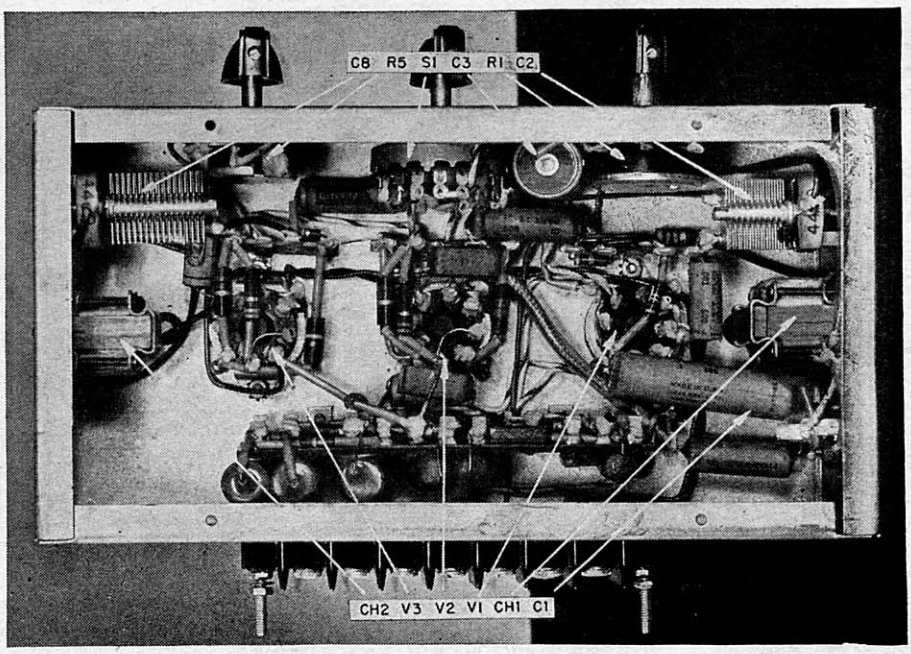
Fig. 2. Circuit diagram of the home-built Dynamic Noise Suppressor.

R^{11}-R^{12}. For any given frequency the attenuation produced by the degenerative signal on the plate of V^2 will vary with the adjustment of C^8 and the setting of R^5. The results obtained may be superior with lower values of R^{10}, or even eliminating it entirely, but the circuit will then be more critical with regard to tube replacement.

When a signal of sufficient magnitude to develop an appreciable voltage across

(Continued on page 184)

Fig. 3. Under chassis view showing location of important components.



HIGH FIDELITY
AMPLIFIER KIT
MODEL "CONCERTO"

This kit is a unit of highly advanced design which will meet the exacting requirements of the most discriminating music lover.
This famous reproducer uses eight tubes in a **new circuit design,** and the first kit available to the public using the ***Cathode Follower*** output circuit. This circuit provides remarkable transient response and improves the performance of the loudspeaker itself by heavily damping its resonances.
A very carefully designed tone control system permits separate control of treble and extreme bass registers and while bass boost is substantially greater than with conventional circuits, it does not affect the middle register.
This amplifier accommodates both high and low gain pickups. Incorporates special circuits for G.E. reluctance pickups. Can be used with any microphone or tuner. Complete with tubes, sensibly priced at.....**$32.95**



Kit Model 210
A Three Way Portable Receiver
Operating on either AC or DC or self-contained batteries . . . power switch conveniently located on front of set so that "battery" or "AC-DC" may be selected without opening case. Five-inch Alnico 5 permanent magnet dynamic speaker, and case covered with beautifully grained leatherette. Price of model 210 complete with tubes.....**$18.95**



Multitester Kit
Model M-3C
A versatile, compact multitester 4" x 7" x 3" using a 3½" rd. meter of 1000 ohms per volt sensitivity. Employs the following ranges: Volts AC or DC 0/5/50/150/500-/1500. Milliamperes DC 0/5/50/150. Ohms 0/2000/20,000/200,000. Price complete.....**$10.95**

All kits accompanied by a detailed, illustrated instruction sheet. Many other kit models available. Write for catalog K.

RADIO KITS COMPANY
120 Cedar Street — New York 6, N. Y.

WAR SURPLUS



TERRIFIC BARGAINS
DYNAMOTORS

BRAND NEW G.E. 485 KVA, Input 27V.D.C. output 115V.A.C. in original packing. Ea. $4.50

New Dyn, Type S-3416, Input 9 V, output 400 V. .7 Amps and .08 Amps. Ea. $1.50

Dyn. new, Type D, Model No. 5D48b9A, input 20 amps, Output 350 Ma at 1000 V.D.C. Mfg. by G.E. Ea: $4.95

Dyn. new, Model 23350, RCA, Input 27V D.C. 1.75 Amps, Output 285V D.C., .075 Amps, Ea.....$1.75

Dyn. new, Type DY-22/Arc .3V, Input 28V D.C. Output 210V D.C. Duty Cont.....$1.95

NEW G.E. SELSYN CONTROL TRANSFORMERS Model No. 2J1G1, 57.5V, 400 cy. Ea.....$1.00

NEW RADIO RECEIVER, BC-AC-229, aircraft type size 13"x6"x6¼", Ea. $3.95

NEW RADIO RECEIVER U.S. Army, BC-341-A size 6¼"x3¼"x5" Ea. $3.50

RADIO CONTROL BOX, U.S. Army with 3 positions selective switch, volume control. Ea.....50c

JACK BOX new, BC-366, USA signal corp, with 5 positions selective switch, volume control. Ea...50c

RADIO FILTER new FL-8-A, ea.....75c

Adel Clips No. 8, 5 doz. for $1.00

ATTENTION, Experimenters, Inventers, Lab. workers NEW ELECTRIC GENERATORS. While they last 15V., 50 Amps RPM 4200, Mfg. by Bendix, Wt. Approx. 40 lb. Ea.....$10.00

GENERATOR NEW, navy type, output 430V D.C. 80 Watts, RPM 3450, Ea.....$10.00

Send Check or Money Order no COD's

GENERAL SALVAGE COMPANY
Dept. 5, 2920 E. 27th St.
KANSAS CITY, MISSOURI

Within the Industry
(*Continued from page* 30)

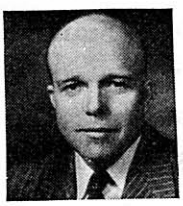
the aptitude and experience of the usual plant maintenance personnel.

An Engineering Department is also maintained to conduct electronic research and development and to perfect new test equipment and techniques as they are developed.

This organization operates nationally and has 10 district offices located throughout the United States.

* * *

A. M. SKELLETT, Director of Research for *National Union Radio Corporation,* Orange, New Jersey, has been appointed Vice President in charge of the Research Division.



Dr. Skellett joined the Research Division of *National Union* as Chief Engineer in 1944 after spending 15 years as a member of the technical staff of the *Bell Telephone Laboratories.* He is a consultant to the Research Development Board in the Department of National Defense of the Federal Government.

* * *

ROBERT J. HARRINGTON has been appointed Assistant Director of Sales for *Industrial Television Inc.* of Clifton, New Jersey.

Prior to joining *Industrial,* Mr. Harrington was Secretary - Treasurer of *American Time Corp.* of Springfield, Massachusetts. He was formerly associated with *Allen B. DuMont Laboratories, Inc.*

In his new post Mr. Harrington will act as assistant to Edwin C. Hinck, the company's Sales Director.

* * *

ROY BROWN UNGER of the *Ward Products Corporation,* manufacturers of radio, television, and auto antennas, has been promoted to the post of sales manager.



Mr. Unger, who served as a first lieutenant of artillery in the Pacific area, was formerly assistant sales manager of the jobber division of *Ward Products.*

Among Mr. Unger's new duties will be an advertising promotion campaign for the company's new FM and television aerial line.

* * *

DR. W. R. G. BAKER, of the *General Electric Company,* representing the Radio Manufacturers Association, was elected vice-chairman of the Electrical Standards Committee of the American Standards Association. Charles R. Harte, of the *Connecticut Company,* New Haven, Connecticut, representing the American Transit Association, was re-elected chairman of the committee.

The Communications and Electronics Section will be under the chairmanship of Dr. Baker while the Power Section will work under the chairmanship of Sidney Withington, chief electrical engineer, *New York, New Haven & Hartford Railroad Company.*

The Electrical Standards Committee of the American Standards Association is the central body for standardization in the United States in the electrical, communications, and electronics field.

New members of the Executive Committee and their organizational affiliations are: L. F. Adams, *General Electric Company,* (NEMA); P. H. Chase, chief engineer, *Philadelphia Electric Company;* L. J. Cumming, technical secretary, IRE; J. J. Pilliod, assistant chief engineer, *American Telephone and Telegraph Company,* (A.I.E.E.); Colonel L. J. Tatom, Commanding Officer, Army Electronic Standards Agency; and C. R. Welborn, executive vice-president, *Underwriters' Laboratories.* —30—

Recording of Sound
(*Continued from page* 61)

R^{22} appears, a negative voltage is applied to the grid of V^2, tending to reduce the transconductance of the tube and reduce the magnitude of the degenerative voltage in its plate circuit. This means that a large input signal to the noise suppressor will produce sufficient negative voltage on the grid circuit of the reactance tube to lower the effective gain and the magnitude of the degenerative voltage in its plate circuit. For this reason the circuit is effectively tuned to a higher frequency when the tube is shifted toward cut-off. These same principles apply to the low frequency reactance tube V^3 except that the signal applied to its grid is produced by a network consisting of a shunt capacitance C^{10} and the resistor R^{14}. This produces a predominance of low frequencies in the grid circuit and a corresponding low frequency degenerative signal in the plate circuit.

The inductance CH^2 is selected to make this circuit resonate sharply to produce a sharp cut-off instead of the roll-off that would be obtained with only an effective shunt capacitance, represented by the reactance tube V^2.

S^1 is used to eliminate the 10 kc. filter under conditions of no suppression and opens the cathode circuit of both reactance tubes, cutting them off completely and eliminating any effect from them. Thus the circuits are virtually eliminated under conditions of "no suppression". In tuning these circuits the procedure is to switch S^1 to the "on" position and unsolder the lead from the

bottom part of S^1 that goes to R^{10}. This leaves the series filter in the circuit but eliminates the reactance tubes. Now, feeding an oscillator (set to 10 kc.) into the input of V^1, tune C^2 for a maximum dip at 10 kc. Next disconnect R^4 from the plate of V^1, switch S^1 to the "on" position, reconnect the lead from R^{10} to the bottom part of S^1, and connect a temporary short across the upper terminals of S^1 (across C^2) thus eliminating the 10 kc. filter but making the reactance tubes effective.

With R^5 set for minimum resistance in the circuit and the oscillator set for approximately 4500 c.p.s., tune C^8 for a maximum dip at this frequency. An output meter may be used for this purpose but it is better to observe the output on an oscilloscope. Now it will be found that adjustment of R^5 to introduce an increasing amount of resistance in the circuit will effectively tune the maximum attenuation dip toward higher frequencies. This adjustment is used in operating the Dynamic Noise Suppressor to determine the frequency where the gates cut-off when they are closed completely. With very good records this control may be operated with almost a maximum of resistance introduced so that the cut-off even when the gates are closed will be above 4500 c.p.s. while with very poor records it will be desirable to operate the control for minimum resistance so as to cut off at lower frequencies. This control may be ganged with S^1 although this is complicated by the availability of suitable components. Under conditions of no suppression, S^1 of course should be used in the "off" position.

In order to observe the operation under effective dynamic conditions, it is necessary to employ two oscillators. One oscillator is fed into the input of the 6B8G and the other oscillator is connected between R^4 (at the point where it was previously disconnected from the plate of V^1) and the cathode of V^1. Now with the output of the oscillator which is connected to R^4, set at zero, the oscillator fed to the input of V^1 is adjusted to provide a signal at, say, 4500 c.p.s. with S^1 in "off" position. With R^5 set for minimum resistance in the circuit, switch S^1 to the "on" position.If the output is observed on an oscilloscope during this procedure the signal will be observed to be greatly attenuated when the switch is operated as indicated.

The output of the oscillator connected to R^4 should now be adjusted to approximately 2000 c.p.s. and the output level slowly increased. It will be seen that this will effectively drive open the gates and bring the 4500 c.p.s. signal back in the direction of no attenuation.

The point at which the noise suppressor circuits are connected in any given

Take 'em Away!!!

DYNAMOTORS
Model 515 Transmitting: Output 500 V. @ 50 Ma., $2.69; 2 for.....$5.00
Model 516 Receiving: Output 275 V. @ 110 Ma., $1.69; 2 for..... 3.00
One of each type..... 4.00
Input: 12 to 24 VDC (Navy Type). These are high efficiency units using PM Fields. May be used on 6 V. input with half of the above output voltages.
DM-416 Input: 28 V. @ 3.1 Amps. Output: 330 V. @ 170 Ma. (Navy Type). Filter assembly in base. Mounting included. New.....$1.49

VIBROPACK
PE-125 BX for SCR-223. Input: 12 or 24 V. Output: 475 V. @ 200 Ma. A heavy duty unit built for continuous service. Complete with 2 RK-60 Rectifier tubes. Spare vibrator, Shock Mount and Plug. Ideal for Mobile installations on cabs, trucks, buses, etc. New. Ready for operation $8.95

METERS (Name Brands—New and Like-new)
0-500 Ma DC 3" Round.....$1.49
0-500 VDC @ 1000 ohms per V. 3" Round..... 2.49
0-10 output units (1.25 Ma. F.S.) in wood case. 2½" Bakelite case (Less thermal unit)..... 2.19
0-15 VDC @ 100/opv 2½" Bakelite case..... .98
0-50 Amps. DC (less shunt) 2½" metal case (F.S.-50 MV) 1.49
20-0-20 Amps. Charging Meter 2½" metal case. With mounting bracket ..... .69

TELETYPE METERS
Bias Meter I-97A-Zero center. 3" Bakelite case. Reads 115 VDC and 100 Ma + or —. Mounted in sturdy steel case. 5" H., 7" L., 4½" D. Contains cond., trans., plugs, cords and many useful parts. Diagram included. A giveaway $4.95
Line Unit BE-77-B Same meter as above. Mounted in sloping panel steel case. 5½" H., 8" L., 6" W. Diagram etched on side. Operating instructions on opposite side. Contains switches, relays, precision resistors and many useful precision parts. Just..$6.95

POTENTIOMETERS (Name Brands)
Dual Unit. Wirewound, with dial plate and knob. Front section: 1200 ohms @ .35 Amps. Rear section: 3 ohms @ 4.7 Amps. Air-cooled. Includes mounting bracket. New $1.29
Dual Unit. Carbon, 4 megs each section. Shaft extends ½". Standard ⅜" mounting.....49c
DUAL. Carbon, 100,000 ohms each. Shaft protrudes ¼" slotted for screwdriver adjustment 39c
Four Gang. Carbon, 1" shaft. Front to back: 6000; 2500; 30,000; 30,000 ohms. Well-made. Sturdy construction 79c
Aircraft Type. 500 ohms wirewound. Enclosed in heavy cast aluminum case. ¼" shaft. Amphenol connector terminals. Only 49c
Rheostat. 90 ohms baked enamel wirewound. Air-cooled in metal case. ⅜" Mtg. ¼" shaft, 1" long. 0.35 Amps. NEW only 59c
Stage Dimming Rheostat. Heavy duty. Asbestos baked element. Tap-switch type. Rated 8 to 25 V. @ 11 Amps. Overall dia. 9. Depth 5". Complete with knob and panel plate. Slightly used.....$2.69

TG-10 PHOTO ELECTRIC CODE KEYER
A Heavy duty unit which may be easily converted to a beautiful high fidelity 25 Watt amplifier for Mic. and Phono. Has complete 110 VAC power supply. Uses 2-6SJ7, 2-6N7, 2-6L6 and 1-5U4G tubes. (less tubes, tapes or reels.) Like New.....$19.95

TURNTABLES
10" for G.I. phono motor. Brand New 39c

PL-68 MICROPHONE PLUGS
3 contacts. Specially priced.....3 for 29c

ALUMINUM RIVETS
Assorted .....Lb. 75c

LOOM
Weather-proof. Heavy fabric. Ideal for sleeving on TV. or FM. lead-ins, thru skylights or around corners. Inside dia.: ¼", ½", ⅝" (specify size). Minimum order 50 Feet. Any size.....50 Feet $1.45

COMPASS REMOTE CABLES
Used with MN-26, BC433G, RA-10, etc., 20 Feet long. Has spline couplings on both ends. New...$2.39

HOOK-UP WIRE
Assorted colors, lengths and gauges. Lb.....75c

RELAY RACK PANELS
.051 thick, hard aluminum, standard notched. 19"x 10½" (unfinished) .....Each 69c

COAX CONNECTORS
10 assorted. Standard types.....$1.49

HEADSETS
HS-30 Ear plug type. Complete. Pair.....98c
HS-16 Standard makes (slightly used) Pair.....98c

PULSE TRANSMITTER—RADAR
ASB-5. 800 cyc. power supply. Uses 1-15R and 4-15T tubes. A great parts buy! Includes Tubes! Like New $9.50

BC-729C ANTENNA TUNING UNIT
For BC-610 Transmitter. (less condenser and case) A few left. Just.....$7.95

B.C. 454-B RECEIVERS
3-6 Mc. aircraft receiver. Like New.....$4.95

WAVE GUIDES
Fine milled. Silver plated. Slate gray finish. 5 foot lengths with connector at each end. Approx. 3 cm. Per foot 75c

TUNING ASSEMBLY
Contains 2-Ft-243 crystals; 3245 KC and 3700 KC (can be used on 10 M. phone) 2-coils, 1-140 mmf. Variable air trimmer, dual xtal socket and case. A Super Value 95c

MT 5/ARR-2 SHOCK MOUNTS
To fit single receiver rack of 274-N series. New. Each 59c; 2 for.....$1.00

SCR-522-VHF TRANS. & RECVR.
The Hams' dream on 2 meters! Ask the man who owns one. Our units are in wonderful condition. Like new, with tubes and two power plugs. Just $19.95

HEAD AND CHEST SET
New. Boxed. Well-known brand. Each.....$1.79

AS/ARN-5 ANTENNA
New. Each $2.95

TRANSMITTING CONDENSERS—*Fresh Stocks*
Leading Brands!
4 Mfd. 800 VDC Size: 1½"x1½"x4½" Can. Each .....$ .69
1 Mfd. 2000 WVDC Size: 1⅜"x2½"x5" Can. Each 1.79
3 Mfd. 2000 WVDC Size: 1½"x3¾"x5¾" Can. Each 2.35
5 Mfd. 2000 WVDC Size: 2⅛"x3⅝"x5⅝" Can. Each 4.39
1 Mfd. 6000 WVDC Size: 2¼"x7"x9" Can. Each 5.95

★ ★ **THIS MONTH ONLY** ★ ★
UNITED SURPLUS Surprise "Package".....$1.29
More than 10 Lbs. of assorted electronic units and parts.

★ ***Write for FREE copy of UNITED SURPLUS 1948 CATALOG***

● ***Quantities are limited—Order Now! Prices subject to change without notice.***
● ***Minimum order—$2.00; 25% Deposit Required. Balance C.O.D. All orders shipped f.o.b. Chicago.***

UNITED SURPLUS MATERIALS
3313-19 W. OGDEN AVE. **CHICAGO 23, ILL.**

Radio Technician and Announcers
A practical 15-month course in First Class Radiotelephone Operation and Announcing is offered by Don Martin School of Radio Arts. Most stations these days require combination men. We specialize in this type of training and maintain a placement bureau for our graduates. Serving the Industry for 10 years, the School of Radio Arts can train you. Write for our catalogue outlining the courses offered. Classes can be arranged so you can do part time work on the side.
APPROVED FOR VETERANS
DON MARTIN SCHOOL OF RADIO ARTS
1655 North Cherokee St. Hollywood 28, Calif.

Serving Radio & Appliance
SERVICE DEALERS
With **4** FROM COAST TO COAST **JOB CARDS**
ASK FOR SAMPLES **RADIO PRESS** MORGANTOWN WEST VIRGINIA

FM-RADIO-TV
PRACTICAL TRAINING
Four fully-equipped laboratories provide the PRACTICAL training essential for successful careers in Radio Communications (FCC licenses) and in Radio-Television Servicing (Technician). Train under the supervision of technical specialists—with commercial-type equipment. Investigate why WRCI SPECIALIZED TRAINING methods are outstanding; why WRCI laboratory-trained specialists are in demand. Read our illustrated bulletin before enrolling in any school. Approved for veteran training—non-veterans accepted. Send for free copy of Bulletin "G" today.
Western Radio Communications Institute
Specialists in Radio-Electronics Training
341 WEST 18TH ST. LOS ANGELES 15, CALIF.

WAR SURPLUS

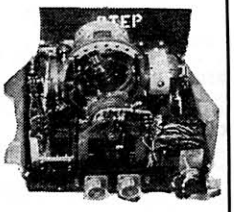
BRAND NEW

A New Supply of Sperry A-5 Automatic Pilot Components

VERTICAL GYRO UNIT

Originally Cost $2855.00

NOW ONLY $14.95



Aluminum housing • One 400-cycle, 115-v., 3-ph. Motor Propelled Gyro • Two 24-v. DC shunt-wound motors • 2 Electronic Relays • Auto Transformer • Hundreds of precision parts • 35 lbs.



AMPLIFIER RACK

With Relays and Meters

Only $6.95

- Mag. Cabinet • 7 DPDT Allied Relays
- 1 SPST Relay • 1 Weston 0-125 AC Volt Meter
- 1 350 to 450-cycle Frequency Meter
- 1 115-volt, 400-cyc. Transformer
- And many other parts • 25 lbs.

Special! Combination Offer!

VERTICAL GYRO and AMPLIFIER RACK Together at $19.95

You pay shipping costs. Send check or money order to

SURPLEX RETAIL SALES INC.

2409 S. LaSalle St., Chicago 16, Ill.

Dept. RN-5 Phone CALumet 9130

Prepare For A Good Job Now in

RADIO

SOUND and TELEVISION



LEARN QUICKLY IN THE GREAT SHOPS OF

COYNE

NOT A "HOME STUDY" COURSE

Get ready for a better job, bigger pay NOW in Radio. Cash in with "All-around" knowledge of Radio—Sound—Television. Train on actual equipment not by "Home-study". You learn quickest at COYNE because it's a real SHOP course!

G. I. APPROVED . . also Finance Plan for NON-VETERANS. Don't let lack of cash hold you back. Many earn while learning. FREE Employment Service to graduates. Get facts today!

SEND COUPON FOR FREE BOOK

Send at once for Big Free Book on Radio, Sound and Television, and facts about our Finance Plan.

MAIL THIS COUPON TODAY

B.W. COOKE, Pres.,
Coyne Electrical and Radio School
500 S. Paulina St., Dept. 58-1K, Chicago 12, Ill.

Please send Big FREE Book and complete details.

NAME .....

STREET .....

CITY ..... STATE .....

amplifying system is, of course, extremely important. If they are connected too near the input and with excessive gain following them, the hum pickup from the inductances may be amplified to an irritating level. If they are connected too far back in the amplifier, the drive to the grids of the reactance tubes may introduce distortion. If the drive to the reactance tube grids is too high, a certain amount of grid rectification will take place with serious distortion. This may be readily observed on the oscilloscope by observing the output in the attenuated regions blown up sufficiently on the screen to see the waveform.

If the circuits are properly adjusted, there will be no observable distortion at any frequency. If the gates are being overdriven, the waveform in some sections of the attenuated region will be seriously distorted. This distortion will be evident under conditions where the gates are driven partially open by a control voltage, but will not appear when the gates are driven fully open. Such an indication clearly shows the introduction of the distortion by the gate tube circuits. If the input signal is of the correct magnitude, this will not be observed and the signal will be entirely clean in all sections of the spectrum under all conditions of gate circuit operation.

It will be clear that this distortion is not a problem of the same kind that is introduced in various volume expander circuits where a variable mu tube is used as an amplifier. The function of the reactance tube circuits is concerned with the proper *percentage* of the signal being fed to the grids and the principles will hold for any given amount of signal supplied, provided it is not so high as to cause grid circuit rectification. Consequently, the operating point with regard to signal amplitude may be chosen to preclude the possibility of distortion on peaks and yet be sufficient so that excessive amplification is not needed in following circuits. This condition is also less troublesome because on peaks where distortion might be otherwise introduced (if the choice of signal amplitude is not optimum) the gates are driven open and the reactance tubes effectively made inoperative. Then any distortion that might be present is observable only under conditions of attenuation. This is not intended to indicate that the distortion introduced by an excessive signal level to the gates is unimportant, but that it is not always easy to observe and should be watched for and investigated with care.

This version of the Dynamic Noise Suppressor will provide, with optimum adjustments, satisfactory operation out to approximately 6000 cycles. If it is desirable to increase the roll-off, where the majority of records played have unusually poor signal-to-noise ratios, a small condenser may be inserted from the junction of R^6 and R^7 to ground. This may approximate 250 $\mu\mu$fd. and will also aid in holding down any tendency of the resonant circuit to permit a rise above cut-off. If it is desirable to broaden the response range, an additional reactance tube may be used instead of this condenser and the values may be approximately the same as those for V^2.

The inductance CH^2 is not necessary in such a circuit. If very wide range response is desired, additional complete filter sections may be added, tuned to increasingly higher cut-off frequencies. In either case the control voltage to these additional circuits may require an additional section of filtering in order to eliminate possibilities of in-phase signals to the grids of the reactance tubes, producing oscillation or distortion. Abrupt surges in the plate circuit of the low frequency reactance tube may appear in the output of the amplifier, if the low frequency response is extremely good and this may be minimized by the choice of value for C^{12} or other coupling condensers. If it is introduced by the filtering characteristics of the control circuits, it may be controlled by an additional filter section. Resistors R^{23} and R^{22} determine the closing speed of the gate circuits and may be changed in value by the individual designer in order to produce faster or slower closing of the gates. These may be reduced to as low as one megohm or even a half megohm. Optimum values will depend to some degree on the taste of the listener, the importance of reverberation in the type of recordings most played and the signal-to-noise ratios of the average records to be reproduced.

Volume Expansion

If the reactance tube circuits are adjusted so that the effective *"Q"* of the circuit is poor, there will be a large resistive component. This means that the shunting effect of the circuits under conditions of closed gates will be apparent to some degree at all frequencies. Consequently, when the gates are driven open the response at all frequencies will be increased to some degree. This effect may be deliberately introduced to produce volume expansion. One way to accomplish this is to change the resistor from screen to ground in the low frequency reactance tube circuit. Adjustment of the screen voltage for maximum *"Q"* is fairly critical. In general, it is desirable to minimize the effect of volume expansion to 2 db. or less. The effect may be deliberately introduced by inserting a potentiometer in place of the screen-to-cathode resistor. The value should be around 10,000 ohms and varying this resistor will produce varying

degrees of volume expansion. As much as 15 db. may be obtained. The expansion will take place simultaneously with the opening of the gate circuits. In these circuits it must be remembered that a really complex effect is obtained if the frequency response and over-all amplitude is being expanded simultaneously. The desirability of this effect, except in very limited amounts, is questionable.

Although this version of the Dynamic Noise Suppressor does not permit sufficiently broad-band response to provide maximum frequency response from transcriptions and commercial pressings of exceptional quality, it does permit superior results on average records over what may be obtained with conventional tone controls. Most commercial records do not have appreciable response in the very high ranges. If it is borne in mind that many very high quality theater sound systems are not required by the signal available to reproduce frequencies beyond approximately 7500 c.p.s., and that music reproduction in high quality theater installations from sound on film is considerably closer to reality than the very great majority of phonograph record reproducers, it will be evident that a system capable of actually reproducing a flat response to 6000 c.p.s. with contribution beyond this frequency, and a minimum of noise, will do a very satisfactory job of reproducing most records, and will be very much superior to the average commercial machine that cuts off abruptly at 4500 c.p.s. in order to minimize noise.

Most of the component parts values are critical, particularly the chokes, CH^1 and CH^2. Therefore, no attempt should be made to substitute either tubes or parts.

Some practice in using the Dynamic Noise Suppressor will be necessary in order to take full advantage of the results it is capable of giving.

(To be continued)

TV OUTPUT UP

OUTPUT of television receivers for February reached a new high of 35,889, according to data released by Radio Manufacturers Association on production by member-companies.

This tops the previous high of 30,001 reached in January of this year. Total production of television receivers since the war now numbers 250,937 units.

More than two-thirds, or 25,594 of the February TV set production were table models, the remainder being consoles and radio-phonograph combinations.

FM-AM receivers reported by member-companies for February totaled 140,629 or an increase of 4614 over January, but still below the monthly average of the last quarter of 1947. About 36 per-cent of the FM-AM units were table models and converters.

Over-all set production by member-companies reached 1,379,605 units of all types in February. —30—

A Sensational New Invention That Will Revolutionize Television: A Liquid Magnifying Lens Using New Patent Principle Allowing Vision From Any Angle Up To 180°

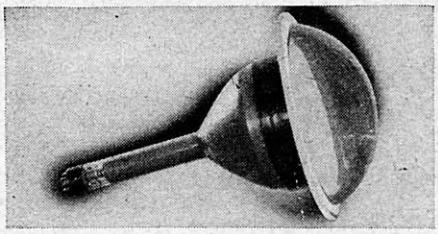
"ALL-VUE" LENS ◆

Front view of the remarkable, new "All-Vue" liquid lens. Actually makes a picture size equivalent to a 15" tube on a 10" set ***without conversion.*** Gives results never obtained before. Now you can watch television for hours without eyestrain. Picture can be seen from all sides.

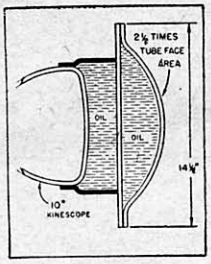
"ALL-VUE" available on order only.

Prices on request.





The Liquid Lens Corporation magnifier. The black collar connects the kinescope with the lens. Space between the fluorescent screen and magnifier screen is filled with oil.



Cross section sketch of the coupling arrangement and oil chambers of the liquid lens.

For additional information and descriptive literature, write to LIQUID LENS CORP.

Our Stock Line of 80° Hang-on Lenses Available Now For Immediate Delivery!

RCA 630	Crosley 10" Table Model	Motorola VT71 (7") 10" Console
8TS30	Philco 1000	Belmont 7" Table Model
721	1001	Admiral 10" Console
621 (7")	700 (7")	Fada 10" Table Model
721 TCS	10" Console	deWald 10" Table Model

Lenses for most other popular sets on order.

All 10" lenses....$19.95 • **All 14½" lenses....$29.95**

"Leading the Lens Field in Television"

LIQUID LENS CORP.

77-17 Parson Blvd., Flushing, N. Y. • JA 3-2004

WRITE.....WIRE.....PHONE FOR DETAILS

FM Coil & Condenser Kit for RCA Tuner

As diagrammed in Receiving Tube Manual Ratio Detector, 3-Gang Condenser, 3 Front End Coils, 2 IF's, 5 Chokes CHASSIS LAYOUT & INSTRUCTIONS **$5.75** Postpaid in U.S.

C-B MFG. CO. 412 W. 37th St., N. Y. 18, N. Y.

ELECTRICAL TRAINING

Intensive 32 weeks' residence course in fundamentals of industrial electrical engineering, including radio, electronics. Prepares for technician, engineering aides. Approved for veteran training. 54th year. Enter July 26, Nov. 22. Catalog.

BLISS ELECTRICAL SCHOOL 7698 Takoma Avenue, Washington 12, D. C.

Mr. Radio Service Dealer

"Speed is our Motto"

One day service on all orders. None too small. Only Nationally Advertised Merchandise (No Surplus Handled). TUBES—Any quantity 50% off list.

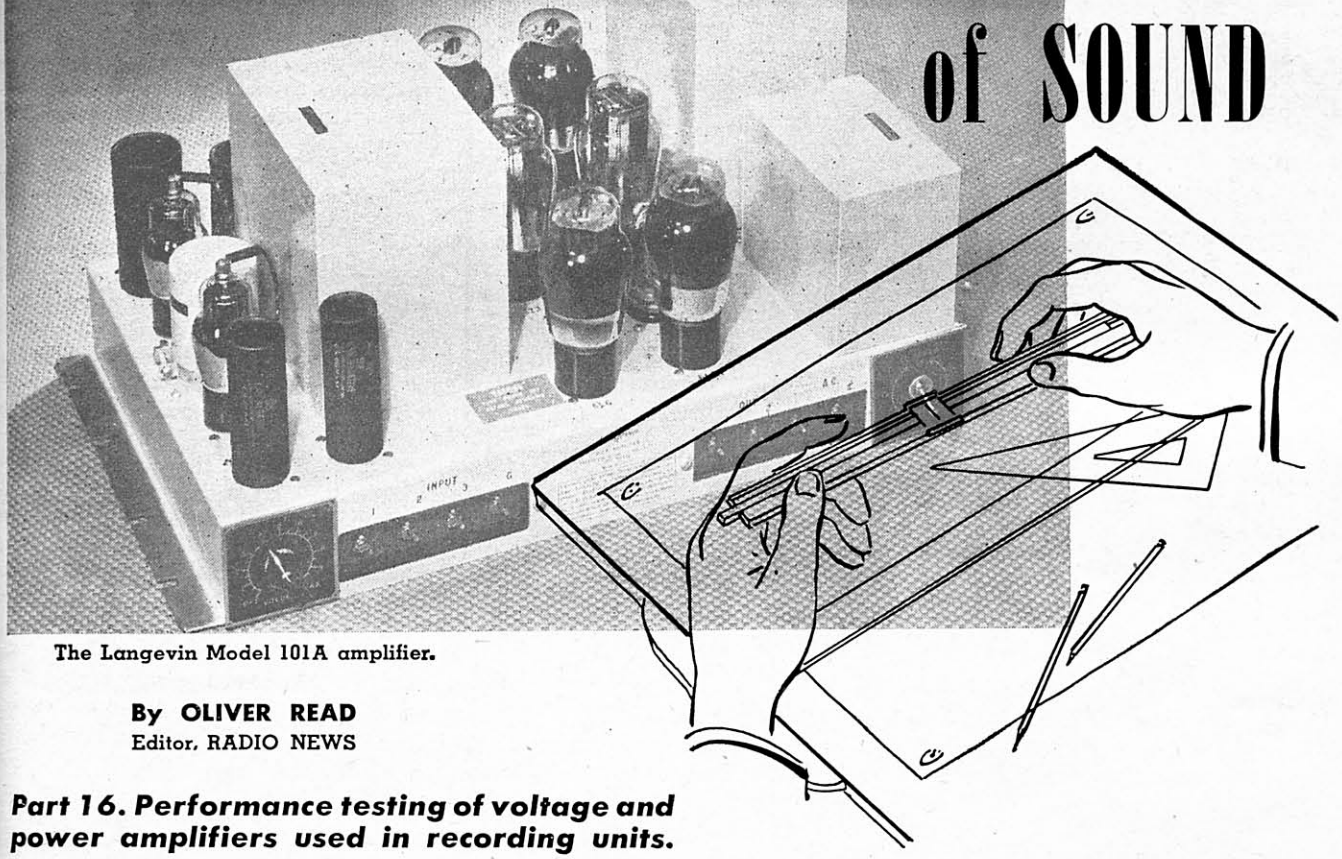
Mail us your orders.

Illustrated list on request.

Bill Sutton's Wholesale Electronics

Fifth at Commerce Fort Worth, Texas

The RECORDING and REPRODUCTION of SOUND



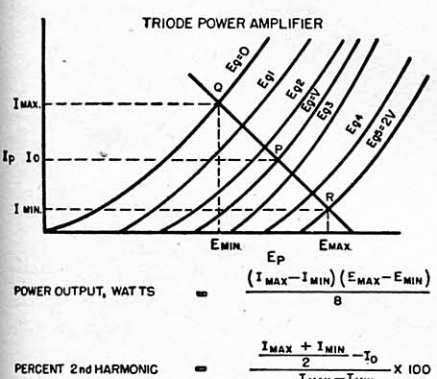
The Langevin Model 101A amplifier.

By OLIVER READ
Editor, RADIO NEWS

Part 16. Performance testing of voltage and power amplifiers used in recording units.

AMPLIFIERS may be divided into two classifications, i.e., *voltage* amplifiers and *power* amplifiers. A voltage amplifier is an amplifier which is intended to deliver a large alternating voltage into a high resistance load. The power amplifier is designed to deliver appreciable power and may or may not require power to drive the grid circuit.

Fig. 1.



$$\text{POWER OUTPUT, WATTS} = \frac{(I_{MAX}-I_{MIN})(E_{MAX}-E_{MIN})}{8}$$

$$\text{PERCENT 2nd HARMONIC} = \frac{\frac{I_{MAX}+I_{MIN}}{2}-I_O}{I_{MAX}-I_{MIN}} \times 100$$

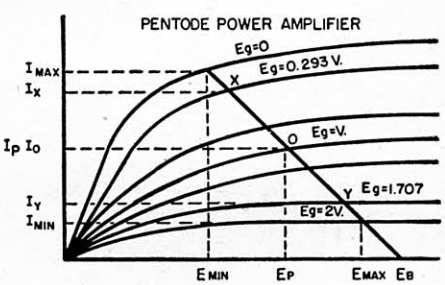
Amplifiers are also divided according to their method of operation into class A, class AB, class B, and class C amplifiers. In a class A amplifier the plate current is a faithful reproduction of the waveform of the applied grid voltage over a complete cycle; in a class AB amplifier this is the case for more than 180 degrees but less than 360 degrees; in a class B amplifier for only 180 degrees and in a class C amplifier for less than 180 degrees.

Multi-stage amplifiers generally consist of several stages of voltage amplification followed by one or more stages of power amplification. The total amplification is limited by miscellaneous noises such as thermal agitation and shot effect which occur in the first stage and are amplified along with the signal. When the amplification becomes so great that these noises become a large part of the output, the amplifier becomes useless. Therefore, it is necessary to keep the noise down, especially in the first stage. Operating the units at lower voltages and using special tubes are some of the remedies employed.

In multi-stage design it is important to proportion the stages so that none of the early stages can become overloaded before maximum output is obtained in later stages. Such a condition may occur if the volume control is placed in the second stage and the input device delivers more voltage than the bias of the first stage. Placing the volume control in a later stage will make the condition worse unless the amplifier is to be used for only one input device of very low output. In general, it is best to put the volume control in the earliest possible stage and to place tubes with low bias and high gain first.

A tube used as a voltage amplifier delivers maximum amplification (equal to mu) if the a.c. load is infinite and the actual plate voltage remains at the rated value. The gain drops with the plate load and with the plate voltage,

Fig. 2.



$$\text{POWER OUTPUT, WATTS} = \frac{[I_{MAX}-I_{MIN}+1.41(I_X-I_Y)]^2 R_P}{32}$$

$$\text{PERCENT 2nd HARMONIC} = \frac{I_{MAX}+I_{MIN}-2I_O}{I_{MAX}-I_{MIN}+1.41(I_X-I_Y)} \times 100$$

$$\text{PERCENT 3rd HARMONIC} = \frac{I_{MAX}-I_{MIN}-1.41(I_X-I_Y)}{I_{MAX}-I_{MIN}+1.41(I_X-I_Y)} \times 100$$

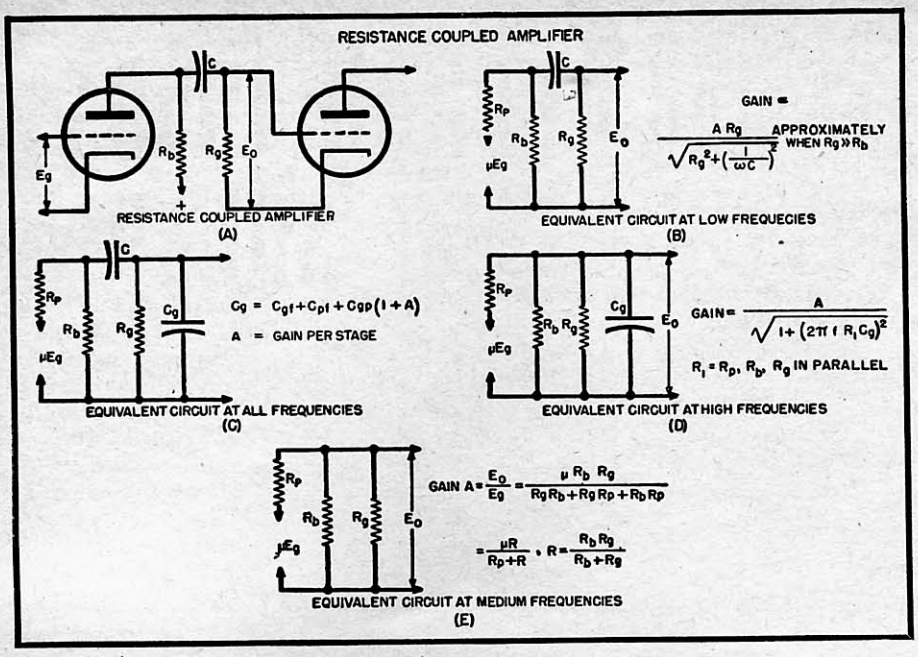


Fig. 3.

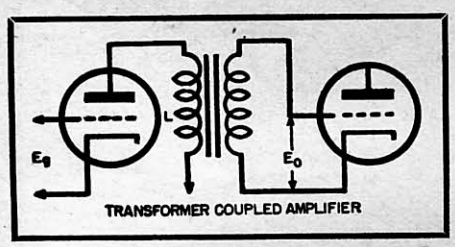


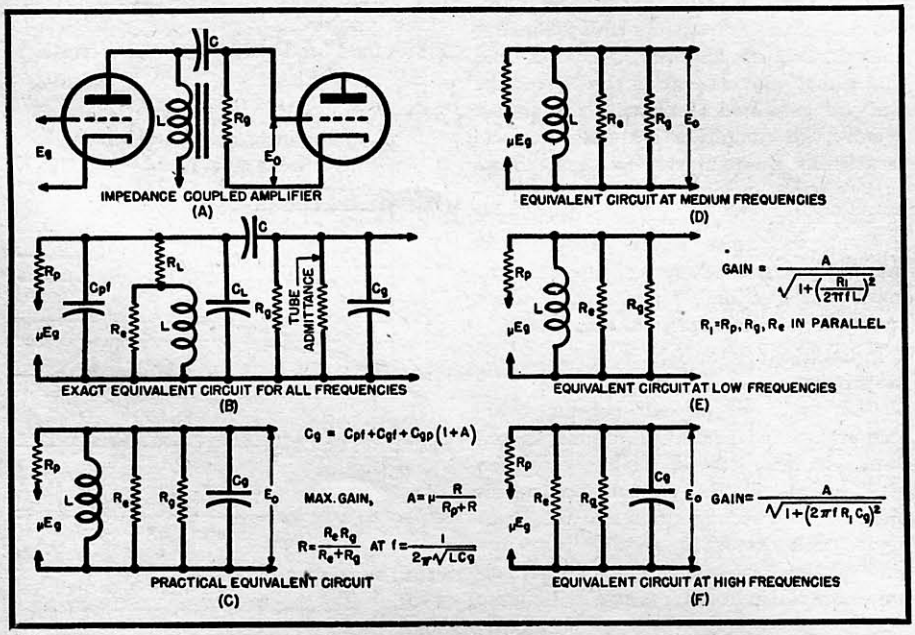
Fig. 4.

so that the best compromise of plate load and plate voltage must be determined. Other problems, such as parallel capacitance, must be taken into consideration.

The obtainable gain and the maximum output as well as the distortion of any tube can be determined for any load and power supply by a geometrical construction on the plate family of curves (*Ep—Ip* curves). When the load has the same a.c. and d.c. resistance, the load line is drawn from the plate supply point on the *X* axis at a slope equal to $1/R$ or I/E, taking into consideration the scale of units employed along the coordinate axes. An operating point is then selected, representing the fixed grid bias; variations in plate current and plate voltage for any grid voltage can then be read. The load should be so selected that the intersections of grid voltage lines are regularly spaced.

When the a.c. load is different from the d.c. load, a load line should first be drawn corresponding in slope to the d.c. load and starting from the plate voltage point on the *X* axis. At the chosen operating point the real load line should be constructed at a slope corresponding to the a.c. load resistance. Maximum output and gain are immediately apparent from the curves.

Fig. 5.



Power Amplifiers

Maximum undistorted output is obtained from triodes when the load equals $2Rp$, for pentodes when the load is approximately 1/5th Rp. The performance as a single-ended class A amplifier can be predicted from the *Ep-Ip* curves as shown in the example in Fig. 1. Draw the load line through the chosen operating point at the slope corresponding to the a.c. load (the d.c. resistance is usually negligible). For minimum distortion, the segments of the load line, *PQ* and *PR* should be equal. When the ratio of their respective lengths is 9:11, the harmonic distortion is five per-cent.

In Fig. 1 maximum power output and harmonic distortion is given in the equations. Fig. 2 gives the same data for pentodes. The gain of amplifiers is often given in decibels. The decibel is a logarithmic unit, expressing the ratio between two magnitudes of power. Mathematically:

$$\text{db.} = 10 \log (P_1/P_2)$$

where P_1 and P_2 are the output and input power (in watts) respectively of the amplifier.

When the impedance at input and output are equal, the decibel may also be expressed in terms of voltages or currents:

$$\text{db.} = 20 \log (E_1/E_2)$$
$$\text{db.} = 20 \log (I_1/I_2)$$

The decibel is used, in addition, as a unit of loss and gain in networks. Although the decibel is not an absolute unit of power level, it can be used to indicate the power level in decibels above or below an arbitrary "zero level." One of the most frequently employed zero levels is 6 milliwatts. In acoustical measurements a zero level of 10^{-16} watts per square cm. has been accepted.

Audio Amplifiers

Audio-frequency amplifiers may be divided according to their type of coupling into resistance-coupled amplifiers, transformer-coupled amplifiers, impedance-coupled amplifiers, and direct-coupled amplifiers.

The charts of Figs. 3, 4, 5, and 6 show the fundamental circuits. Complete information on the constants for resistance-coupled amplifiers and their performance will be found in tube manuals.

Resistance-coupled amplifiers have the advantage of economy while the frequency response can be made nearly flat. The phase distortion is less than that of other types of coupling except direct coupling. Disadvantages include lower gain than impedance or transformer coupling with the same tubes and power supply and the tendency to "motorboating."

Impedance-coupled amplifiers have a lower voltage drop across the load, thus making the plate voltage higher. The frequency response falls off at the low end as well as at very high frequencies, above the point where parallel resonance occurs. The drop at the low end can be minimized by placing a resistor across the plate choke. If the value of the resistance is 1/3 of the choke reactance at the lowest frequency, or less, the impedance of the combination will not vary more than a few per-cent over the audio range.

At present, transformer-coupled triode amplifiers can be designed to have a frequency characteristic as good as that of a resistance-coupled amplifier. The gain of such amplifiers is not as high as that of the resistance-coupled amplifiers using pentode tubes, and the cost of the transformers is high. When sensitive amplifiers are used and a transformer is at the input, the hum problem is much greater than with RC amplifiers. Well shielded transformers are required and even then critical placing is necessary.

Direct coupling is really a special case of resistance coupling. In such circuits the plate of the first stage is directly connected to the grid of the next, a condition which requires some juggling with power supplies. Since the load between stages is a resistance and the coupling elements per stage are reduced, this type of amplifier can be made to have a better response than most other types. Response at low frequencies is better and delay distortion is less. The main difficulties are the tendency to drift due to temperature changes and the difficulty in designing amplifiers of many stages. It is possible, however, to make an amplifier employing a drift-corrector which makes the system practical for amplification of a.c. signals but not for d.c. Practical circuits for a single-ended amplifier and a push-pull amplifier are shown in Fig. 6.

Feedback

When a portion, B, of the output of an amplifier having a voltage amplification A, is fed back to the input, the gain becomes: $A/(1-AB)$. In this case B is positive for regeneration and negative for degeneration. Non-linear distortion, noise, and hum will be multiplied by the factor: $1/(1-AB)$.

These equations hold when the feedback voltage is in series with the input signal and there are no additional phase shifts due to reactances.

Fig. 7 shows several ways of arranging the feedback circuit in transformer-coupled and resistance-coupled circuits. There is a phase shift of 180 degrees in each stage which should be taken into consideration; in addition, there is a phase shift in each stage which varies with frequency but is never more than 90 degrees. This fact limits the number of stages to be bridged by the feedback circuit. When the sum of the shifts amounts to 180 degrees, oscillation starts unless the gain at that point is less than one. For this reason, degeneration is limited, as a rule, to three stages and to about 30 db.

Measuring Distortion in A.F. Amplifiers

The simplest qualitative test for distortion in a class A audio-frequency amplifier stage may be made, as shown in Fig. 8, by applying a signal voltage of proper level to the input and inspecting the circuit for one or all of the following abnormal conditions:

(a) Presence of d.c. grid current.

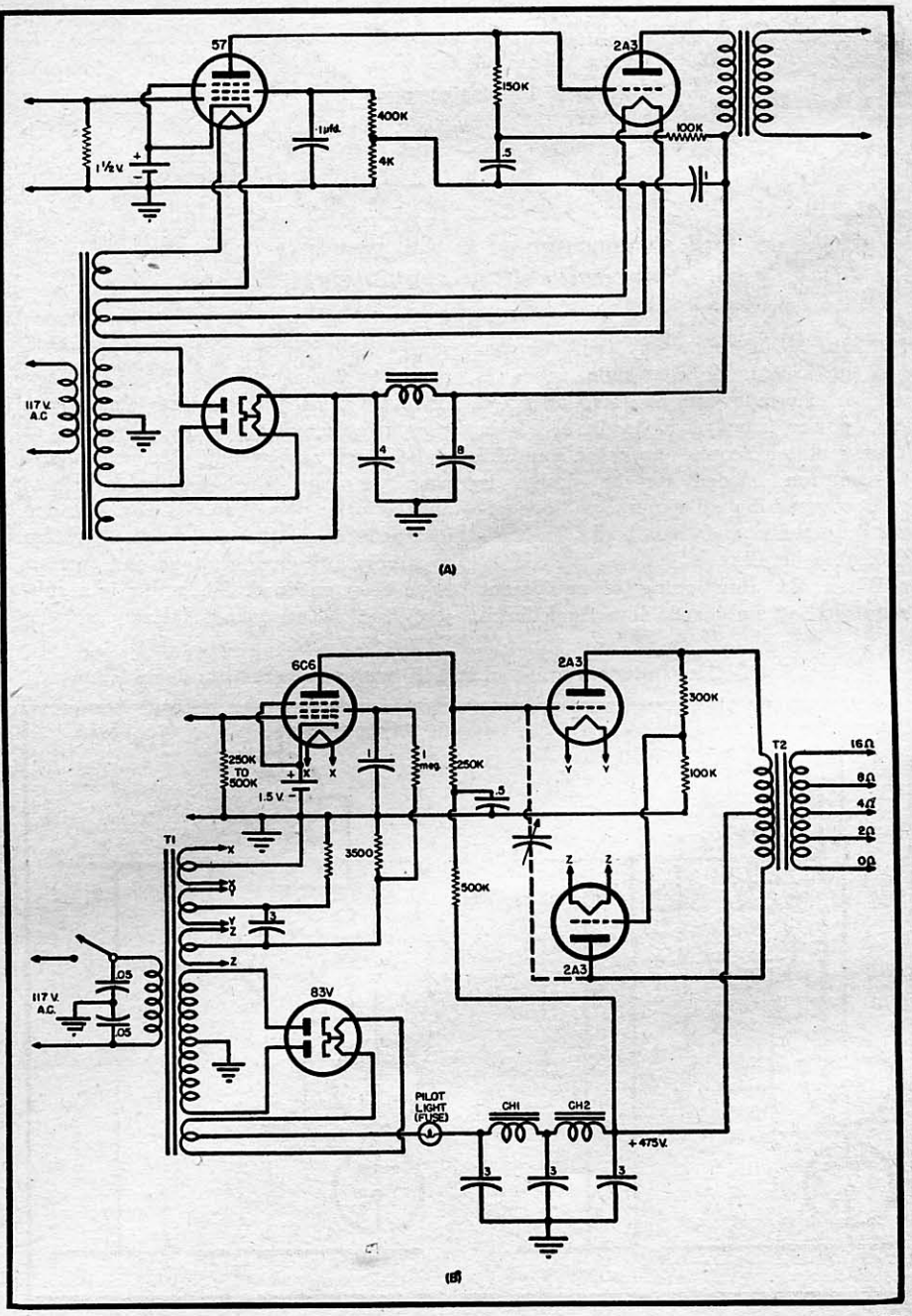
(b) Fluctuation of the d.c. plate current.

(c) Fluctuation of the d.c. cathode voltage, if the circuit employs cathode resistor bias.

Each of these indications generally occurs in a positive direction, and each will disappear upon removal of the signal. It must be borne in mind, however, that this method is purely rudimentary in nature and serves only to detect the presence of distortion. One or two of the indications may be absent, depending upon the main cause of the trouble.

The three simple indications are well known and frequently used by servicemen and p. a. testers who have no equipment suitable for making quantitative distortion measurements, but must, in the course of routine testing, localize distortion without reference to the actual per-cent harmonic energy present. *(Continued on page 165)*

Fig. 6.



provision need be made for any adjustment of injection. Triode converters are noticeably free from a critical value of injection voltage.

If a converter is used, the adjustment is simplicity itself. When construction has been completed, the frequency of the converter oscillator should be set, by adjustment of the tuning slug if a slug-tuned coil is used, or adjustment of the padding condenser if an air core coil is used. If the receiver used is a BC-454, the oscillator should be set to 24 mc. If a BC-455, the oscillator should be placed on 21 mc. A calibrated receiver or frequency meter will be of considerable assistance in this operation.

An antenna should then be connected to the converter and the receiver tuned until a signal is heard. The station transmitter used with a dummy load, or a modulated signal generator may be used to furnish the signal in the event no stations can be heard. When the signal has been tuned in, the coil slug and antenna condenser C_1 should be adjusted simultaneously for maximum signal strength.

When the adjustment has been completed, the signal may be peaked by means of the antenna trimmer on the receiver. This trimmer will require little or no adjustment in tuning over the band.

All tuning is done with the regular dial, and the converter will require no further attention or tuning unless an antenna system with a different feeder impedance is used.

Of the two receivers converted, the BC-454 gave somewhat better performance. Selectivity of this receiver is also somewhat better, being in the vicinity of 7.5 kc. at two times down.

—30—

Recording of Sound

(*Continued from page* 67)

The cathode circuit effects noted are due to fluctuations in the voltage drop across the cathode resistor, occasioned by variations in the d.c. component of plate current. The current indicated by the plate-circuit milliammeter is the average value of the fluctuating "signal" plate current, is identical with the d.c. component, and is the current that produces the cathode resistor drop. These facts may be better comprehended when it is remembered that the fluctuating signal plate current (Fig. 9) is an alternating current, corresponding to the signal, superimposed upon a direct current. It will be evident from the fundamental relations of this combination that the average value of plate current, as indicated by the plate-circuit milliammeter, will be constant in the company of the alternating component under distortionless operating conditions.

STAHL'S ★ Star ★ Studded ★ Specials!!

BC-645A 450MC X-Mitter-Receiver

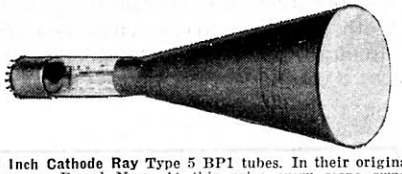
BRAND NEW



Complete with Tubes includes 4-7F7, 4-7H7, 2-7E6, 2-6F6, 2-955 and 1-WE 316A door knob. Can be easily converted for Phone or CW on 420-450Mc Bands..... **$7.95 each**

OIL CONDENSERS

G.E.	1 Mfd	600V DC	.35
	2 "	" "	.40
C.D.	4 "	" "	.50
Aerovox	10 "	" "	.95
	15 "	" "	2.25
Bathtub	1 "	1000V DC	.40
G. E.	.35 "	5000V DC	1.50
G. E.	4 "	1500V DC	1.50
G. E.	1 "	2000V DC	.95
Sprague	1 "	3600V DC	.95



5 Inch Cathode Ray Type 5 BP1 tubes. In their original cartons; Brand New. At this price every scope owner should buy a few, and keep in reserve. How can you go wrong for only $1.95

SCOPE Tubes—2"—2AP1 ..... **$1.95**

Hipower quartz Crystal units, type CF5, 5000 KC, complete with holder $1.95

Jefferson step down (or step up) power circuit transformer double wound 230V input 50 - 60 cycle, to 115V output, 250KVA. Weight 17 lbs. $7.95

RCA-CRV-51019 Hand Sets self contained battery operated. Uses 4 pen light batteries excellent for Television Antenna installation. Sold in pairs only ..... Pair 15.00

Blank Calibration Books for BC 221-Frequency from 125KC to 20000KC printed in .10 divisions —68 pages, aluminum cover, spiral bound....$1.50

METERS

Roller Smith portable lab 0 to 15V D.C. Bakelite Case with handle; 5½ x 6 x 3½ 19.50

Roller Smith portable lab 0 to 150 Mil. D.C. Bakelite Case with handle; 5½ x 6 x 3½ 19.50

4½" **Weston** Panel Board flush metal case 0-5 amp. A.C. with a 0-200 amp. scale 3.95

3" Round **Triplitt** Bakelite Case 0-150 Volts A. C. 3.45

3" Round **Western Electric** Bakelite Case 100-0-100 Milliamps. D.C. 3.45

3" Square Bakelite Case **Westinghouse** 7.5 Volt A.C. 3.45

2" Round **Triplitt** Bakelite Case 0-35 Mill D.C. in Black Wrinkle Finish. Round Metal Box.. 2.25

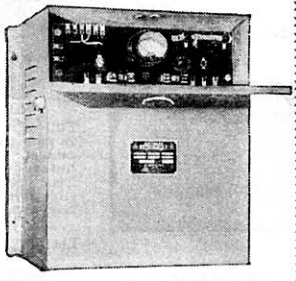
3" Round **Western Electric** 0-1000 Mill D.C. Bakelite Case 2.25

3" Round **Beede** 0-1000 Mill D.C. Bakelite Case 1.95

RAYTHEON RECTICHARGER

W-3155

$49.50



Supply Current at a constant voltage and supplies current to a storage battery, providing an automatic AC - DC power system. Has no moving or expendable parts — therefore no frequent adjustment or maintenance is necessary. The life of the battery increases as much as 40%. Eliminates voltage variations. Range of unit 11/12 cells, 22 to 24 volts @ 3 amp. output. Input supply source 95 to 130 volts, 60 cycles, weight 180 lbs.

Navy Standard Battery (Brand New)



Made by Gould Storage Battery Corp. 6 volt 15 amp hour. Excellent for amateurs, experimenters, radio servicemen, &c. Shipped dry, with complete instructions for charging. 4⅝x4¾x6¾ high. Shipping weight 12 lbs. While they last **$4.95**

Prompt Delivery—Write Dept. RN6.

25% deposit required on C.O.D. order. Shipped F.O.B. New York.

MICHAEL STAHL, INC.

39 VESEY ST.
NEW YORK 7, N. Y.

TELEPHONE
WOrth 4-2882

INSIDE INFO!
Get your copy today



ELEMENTS OF MAGNETIC TAPE RECORDING and 999 APPLICATIONS

Available For Only **25c**

by A. C. SHANEY

Contains schematic diagrams

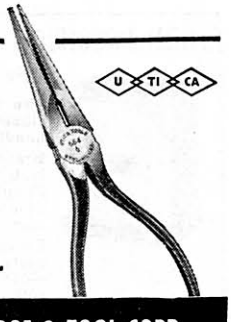
AMPLIFIER CORP. of AMERICA

398-2 Broadway • New York 13, N. Y.

UTICA TOOLS

PLIERS FOR EVERY NEED

TOOL NO. 654-6"



Ask Your Dealer

UTICA DROP FORGE & TOOL CORP.
UTICA, 4 NEW YORK

six "firsts" in radio values



REGAL 1107

Full size table model 6½x7x10, 4 tubes-Superheterodyne, 5" pm speaker, built-in Regaloop, slide rule dial, provision for outside aerial. YOUR COST

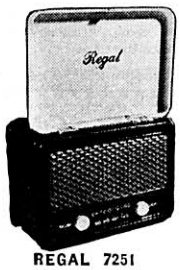
$8.90

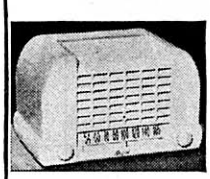
REGAL SUPER-MITE! #777

3 way portable AC-DC & Battery, powerful reception, super-sensitive pickup. Made in lightweight aluminum in several colors. Batteries extra $2.04. Retails $29.95. YOUR COST

$22.22

Lot of 3 $21.72





REGAL 7251

Full size table model in walnut & ivory plastic cabinet. AC-DC superheterodyne, built-in loop, deep rich tone, slide rule dial, excellent reception.

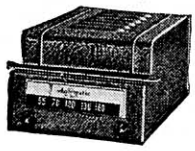
$12.75

Lot of 3 $12.00

AUTOMATIC M-86

6 tube car radio—3 gange variable condenser, one piece unit, easily installed, fits any car. Retails $39.95 YOUR COST

$27.97





TEMPLE G612

6 tube, 3 way portable superheterodyne receiver. Plays anywhere. Batteries extra $4.04 Actual retail $49.50 YOUR COST

$22.22

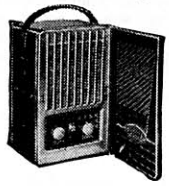
Lot of 3 $21.72

TEMPLE G415

3 way personal portable using latest octal type low drain electronic tubes. Batteries extra $2.26. YOUR COST

$19.50

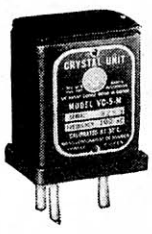
Lot of 3 $18.71



At Least 10% with Order
Balance C.O.D.

NATIONAL RADIO DISTRIBUTORS
899 Southern Blvd., New York 59, N. Y.
LUdlow 9-6015

HIGH PRECISION 100 Kc. CRYSTALS



Price $3.95 each

(No C. O. D.'s. Please include 25c for postage and handling.)

Brand New Surplus at about 1/10 Gov't. cost. An ideal Frequency Standard for Amateurs, Servicemen, Laboratories, etc.

Exceptional Frequency Stability ± 15 cycles from —50° to + 80° c. (.0015) 10G Vibration Test. Calibrated at 30° c. Brand New, Mounted in Sealed Cases as Shown.

ELECTRONICRAFT, Inc.
5 Waverly Place • Tuckahoe, N. Y.

Fig. 9 is a graphical representation of signal plate current. *Imax.* is the maximum value reached by the fluctuating plate current; *Io*, the zero-signal value; *Imin.*, the minimum value. From these values, it may be shown that the percent second-harmonic content (often the most troublesome distortion factor) is equal to:

$$100[\tfrac{1}{2}(Imax+Imin)-Io]/(Imax-Imin)$$

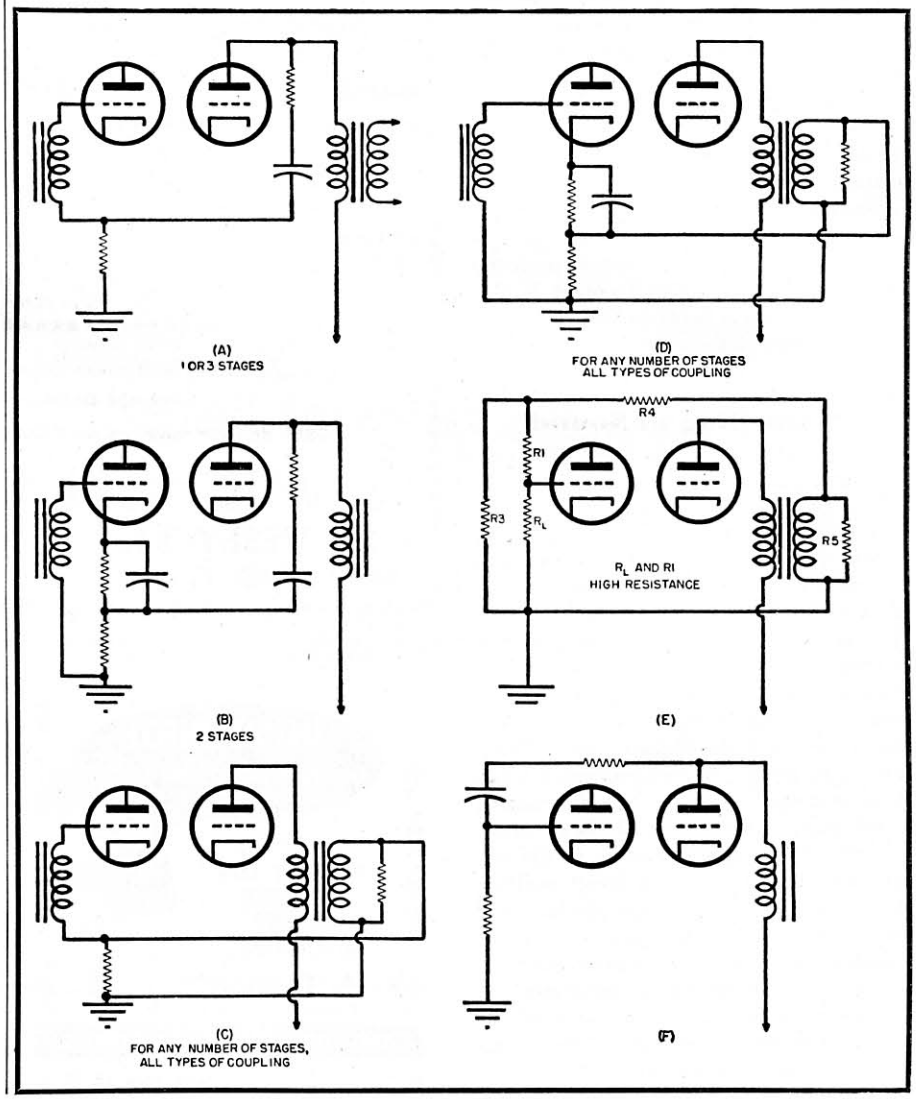
Quantitative methods of checking distortion are *harmonic analyses,* and are concerned with measurement of the actual amount of energy present in each separate harmonic of the signal frequency (or in the total harmonic content) and establishment of percentages with respect to the fundamental frequency. The most representative methods employed in wave analysis and the apparatus necessary thereto will be described presently.

The cathode-ray oscilloscope is notably useful in the observation of wave shapes. When the horizontal plates of the ray tube are energized by a sawtooth wave sweep-oscillator-amplifier circuit to furnish the linear time base, and a signal voltage which it is desired to observe is applied to the vertical plates through a substantially flat-response amplifier, the cathode-ray trace will be an exact reproduction of the waveform of the applied signal voltage.

An audio-frequency amplifier may be checked for distortion with the oscilloscope in the manner illustrated in Fig. 10. At the left is an audio oscillator possessing an output voltage waveform of known purity, next is the amplifier under test, and at the right is an oscilloscope having horizontal and vertical amplifiers with substantially flat frequency responses.

It is the purpose of the oscillator to supply a signal of as pure waveform as practicable to the amplifier, and that of the oscilloscope to reproduce the wave shape of the signal after it has passed through the amplifier. In order that as little distortion as possible be introduced by the instruments themselves, the oscillator used for such a test must be of exceptionally high quality and the amplifiers in the oscilloscope must possess an excellent frequency characteristic.

Fig. 7.



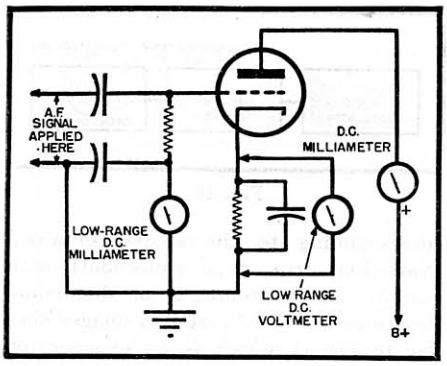


Fig. 8.

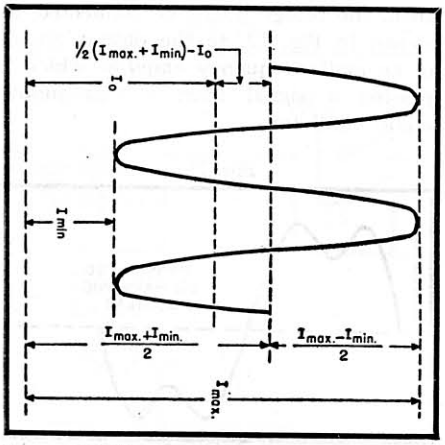
Likewise, the oscilloscope sweep circuit must be uncompromisingly linear in its characteristic.

If the amplifier had no distortion at all, the signal it delivered to the oscilloscope would be an exact reproduction of the input signal waveform. This is never encountered in practice, however, the most efficient amplifier arrangement being beset with the distortion characteristics of its tubes and other components.

For observations, a perfect sine wave (or, better still, a tracing of a single cycle from the test oscillator) might be inscribed on the transparent viewing screen of the oscilloscope, and signals from the amplifier matched to this pattern to discover variations from the original shape due to amplifier distortion. In making such a test, it would of course be necessary to adjust both oscilloscope amplifier gain controls in such a manner that the maximum amplitude and width of the signal trace coincided with those dimensions of the inscribed pattern.

With the low percentages encountered with most well-designed amplifying equipment, it will be difficult to estimate the percentage of harmonic content from the reproduced wave shape, in the oscilloscopic method, unless the operator makes use of the transparent screens furnished by some oscilloscope manufacturers for the purpose. These screens carry printed patterns of single cycles

Fig. 9.



IT PAYS To Buy Hallicrafters

From The Worlds Most Personalized
RADIO SUPPLY HOUSE

LARGE STOCKS



Hallicrafter S-53
$79.50
$15.90 Down

PROFESSIONAL PERFORMANCE

World wide domestic and short wave reception. It's sensitive, powerful, completely dependable. SIMPLIFIED control—anyone can operate the S-53. 540KC to 54.5MC—5 Tuning ranges. Electrical Band Spread-Series Noise Limiter, 2.5 watt audio output. Complete with 7 tubes and built-in speaker.



Hallicrafter SX43
$169.50
$33.90 Down

PREFERRED BY AMATEURS

Hallicrafters SX-43 is designed for the discriminating amateur and short wave fans who demand the finest reception of standard A.M. F.M. Broadcasts. AM 540 KC—55MC.—FM. 44-55 MC; 88-108MC. 6 Frequency Bands—tuned RF stage—High fidelity audio-Automatic Noise Limiter.

Hallicrafters Model No.	Your Price	Down Payment
S-38 540 KC to 32MC in 4 bands. Self contained speaker.	47.50	9.50
S40A 540 KC to 43MC 9 tubes built-in speaker.	89.50	17.80
SX-42 540 KC to 110MC 6 bands FM, AM, CW—15 tubes less speaker	275.00	55.00
S51 140 KC to 12.0MC 4 bands complete with 9 tubes, built-in speaker	129.50	26.00
HT-17 Crystal controlled 10 watts output, CW Xmtr	49.50	9.90
HT-18 Variable Master Oscillator Quality AM with narrow band FM	110.00	22.00
S.P. 44 Panoramic adapter	49.50	9.90
S-47 New FM-AM Receiver, tunes 535 to 108 MC. Push Button Control, 12 watts output, 15 tubes—in cabinet	200.00	40.00



Leo T. Meyerson W9GFQ

Bigger Trade-In Allowances

Fellows—BIGGER TRADE INS—let me know what you have to trade—use as down payment on my personalized payment plan to fit your budget. Get acquainted with me. I have a WORLD REPUTATION for square dealing and hosts of satisfied customers and friends. Ask anyone who has dealt with me—write me today for a PROMPT PERSONAL REPLY.

WRL Guarantees Fast, Personal Service

- Liberal Trade Ins
- Orders Filled Same Day
- Complete Parts Stock
- Ham Gear Our Specialty



Get Acquainted Offer
New up to date Giant Radio Reference Map
Just right for your control room wall. Approximately 28"x42". Contains time zones, amateur zones, leading shortwave stations, monitoring stations, Mail coupon today & 25c.

Get this 68 Page Bargain Catalogue FREE!



WRITE—WIRE PHONE 7795

World Radio LABORATORIES INCORPORATED
EVERYTHING IN RADIO!
COUNCIL BLUFFS, IOWA

WORLD RADIO LABORATORIES
744 West Broadway
Council Bluffs, Iowa

Please send me: Free
☐ Radio Map ☐ Send Hallicrafter
☐ Parts Catalogue illustrated catalog

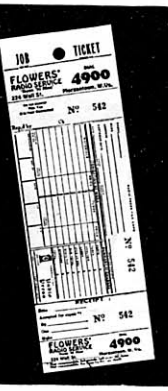
Name.....Call Letters.....
Address.....
City.....Zone.... State.....

Learn and Earn!
TELEVISION
RADIO F. M.
COMMUNICATION

offer profitable occupation for both men and women. You learn by actual work, how to build and operate, and fit yourself for a higher pay job. Write for catalog.

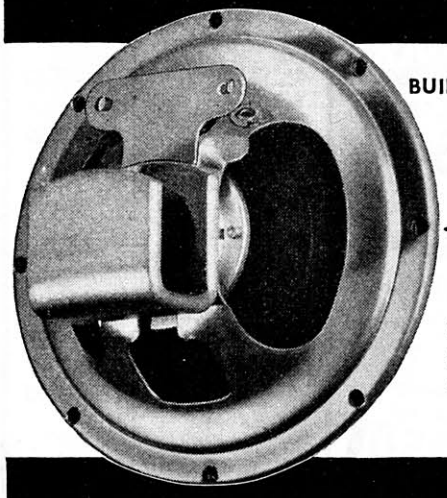
Approved for Veterans

Hollywood Sound Institute, Inc.
1040-A No. Kenmore Hollywood 27, Calif.



$500
MORE PER YEAR!
REPORTED BY
RADIO SERVICE DEALERS
who use
4-in-1
JOB CARDS
Write for details
RADIO PRESS
MORGANTOWN, W. VA.

QUAM *Adjust-a-Cone* SPEAKERS



BUILDERS OF FINE SPEAKERS SINCE 1923

LOOK FOR THE
U-SHAPED
COIL POT

Electro Dynamic and P. M. Speakers in the following sizes: 3½", 4", 4"x6", 5", 5¼", 6½", 6"x9", 7", 8", 10" and 12".

Write for Catalog...

QUAM-NICHOLS COMPANY, 522 East 33rd Place, Chicago 16, Ill.

SENSATIONAL 'MERIT' VALUE

HOTTEST ITEM OUT! Make your SCR-522 Receiver operate on 144 to 148 Mc with ONE DIAL control, in less than 1 hour! Method is completely mechanical. Tracking is adjustable for the individual receiver. Band-spread is adjustable up to about 160 degrees. Parts and instructions **$3.00**

(Please include 8c postage)

MERIT RADIO SUPPLY CO.

471 Merrick Road Lynbrook, N. Y.

GREYLOCK

A Dependable Name in RADIO TUBES

GT, Glass, and Miniature Types

ALL TUBES IN INDIVIDUAL CARTONS

12SA7, 12SK7, 12SQ7, 50L6, 12AT6, 12BA6, 12BE6, 35W4, 50B5 ...each **39c**
1R5, 1S5, 1T4, 3S4, 3Q4, 6AK5, 6AC5, 6AC7, 6AQ5, 6BE6, 6BA6, 6AU6, 6BJ6, 6X4 .....each **49c**
32L7, 70L7, 117L7 .....each **59c**

All Tubes Carry RMA 90-Day Guarantee

PM SPEAKERS

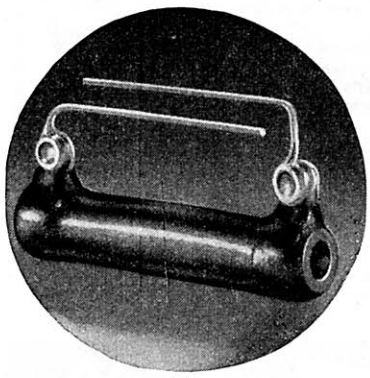
4" Alnico No. 5.....each **$1.19**
5" Alnico No. 5.....each **1.29**

TERMS: Net C.O.D. No order accepted for less than $5.00

Write for Bargain Catalog N-6

GREYLOCK ELECTRONIC SUPPLY CO.

30 Church Street New York 7, N. Y.



Insist on LECTROHM
when you buy
5, 10, & 25 WATT
RESISTORS

Leave it to your LECTROHM dealer to take care of your Resistor needs. He knows you require the best in radio parts — that's why he carries LECTROHM. Built to exceed your specifications, LECTROHM'S 5, 10 and 25 Watt Resistors are accurately spaced, wire wound and permanently sealed in vitreous enamel for long, dependable service. Silver soldered connections assure perfect electrical bond. Today, when every penny counts, insist on the Resistors that give you more for your money — LECTROHM.

Write for Lectrohm's Catalog of valuable Resistor Data — NOW.



LECTROHM INCORPORATED

4906 WEST 25TH PLACE, CICERO 50, ILL.
Division of
National Lock Washer Company, Newark, N. J.

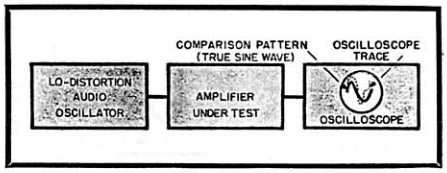


Fig. 10.

corresponding to the shapes obtained (variations from true sinusoidal) with various low percentages of distortion. Severe cases would result in images similar to Fig 11 which is an exaggerated representation of pronounced third-harmonic content.

Frequency Bridges

Certain bridge circuits, notably the Wien bridge (see Fig. 12) can be used for the identification of frequencies in the audio-frequency spectrum. If an alternating voltage is delivered to the bridge circuit, the latter may be adjusted for a null at that particular signal frequency. The null point would not hold for the same voltage of another frequency. Thus the adjustable element of the bridge might be calibrated to read directly in cycles-per-second.

The Wien bridge in its most useful form for this purpose would have its constants so chosen that the ratio arm R_2 is twice the ohmic value of R_1, the condensers C_1 and C_2 are equal in capacitance, and the two simultaneously adjustable resistance legs R_3 and R_4, are at all positions equal. Under these conditions, the frequency of the impressed voltage at null would be equal to:

$$f = 1/2\,\pi\,RC$$

Where:

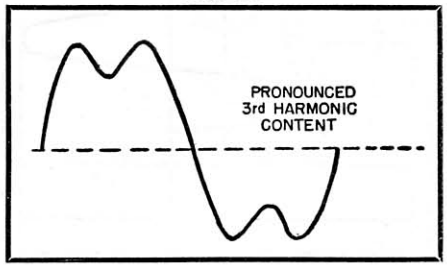
f is the frequency in cycles-per-second,

R is the resistance of R_3 or R_4 in ohms,

C is the capacitance of C_1 or C_2 in farads.

Since the bridge may be balanced for only one frequency at a time, it would appear that any residual voltage indicated by the vacuum-tube voltmeter M, at null would be due to some other frequency or frequencies (such as harmonics of the fundamental.) This harmonic voltage would be due to the total of harmonic voltages present. As such, the bridge might be connected, as shown in Fig. 12, to the output circuit of an audio-frequency ampifier which is passing a signal from a high-quality audio oscillator.

Fig. 11.



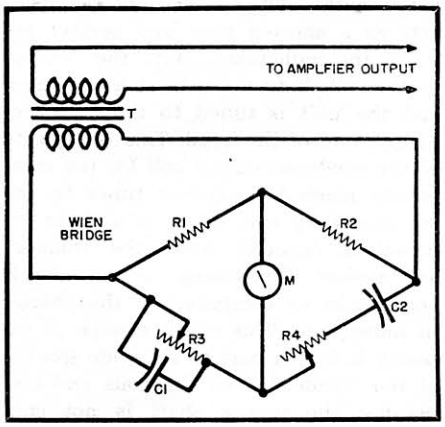


Fig. 12.

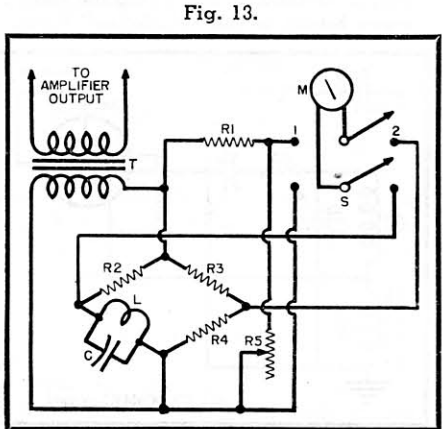
While the device might be used as shown as such a harmonic totalizer, the percentage total harmonic content with respect to the readings of the meter before and after null would not be reliable, nor would its error be uniform for all frequencies. These facts are due to the peculiar inability of the bridge to attenuate various harmonics equally.

Another popular type of bridge harmonic totalizer (developed by *UTC*) is shown in Fig. 13. Here, three legs of the bridge, R_2, R_3, and R_4, contain pure resistance, while the fourth leg contains the shielded parallel resonant circuit, *LC*, which is resonant at the test frequency. The transformer *T*, like the one shown in the bridge previously described, must have an excellent frequency characteristic.

At resonant frequency of *LC*, the inductive reactance of the tuned circuit equals the capacitive reactance, the former is cancelled by the latter, and the bridge balances as if all four legs were pure resistance. Any voltage applied by the circuit to the vacuum-tube voltmeter is then due to harmonics of the test frequency (and it is assumed that these harmonics have been delivered to the bridge by the amplifier under measurement).

In operation, the double-pole, double-throw switch, *S*, is thrown to position 2 and the bridge balanced with the assistance of the vacuum-tube voltmeter,

Fig. 13.



2 out of 3 ESPEY need it!

The Custom-Built Chassis



According to the RMA over 18 million consoles were built BEFORE '44!

That's right! The newest are four years old, and there are more than 11 million of them that are ten years old. Of the 18 million owners, 51%, or over 9 million LIKE their cabinets—in spite of the fact that the vast majority of receivers are hopelessly obsolete, lacking such present-day essentials as FM.

Furthermore, over 90% of the console owners WANT FM, but less than 6% HAVE it. What a replacement market!

It was to fill this tremendous need that ESPEY designed its line of top-quality custom-built chassis, supplied complete and ready to operate in your customers' cabinets.

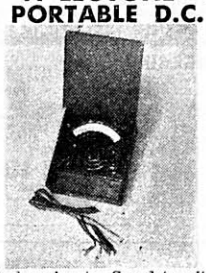
For further details about the ESPEY replacement chassis, and the opportunities in the replacement industry, we urge you to write today to Dept. A-6.

ESPEY MANUFACTURING COMPANY, INC.
528 EAST 72ND STREET-NEW YORK 21, N.Y.
"ESTABLISHED—1928"

RADIO
Technician and Radio Service Courses
FM and TELEVISION
American Radio Institute
101 West 63rd St., New York 23, N. Y.
Approved Under GI Bill of Rights
Licensed by New York State

TELEVISION RECEIVER—$1.00
Complete instructions for building your own television receiver. 16 pages—11"x17" of pictures, pictorial diagrams, clarified schematics, 17"x22" complete schematic diagram and chassis layout. Also booklet of alignment instructions, voltage and resistance tables and trouble-shooting hints.—**All for $1.00.**
CERTIFIED TELEVISION LABORATORIES
5507-13th Ave., Brooklyn 19, N. Y.

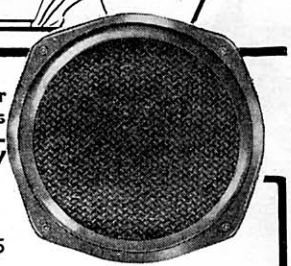
A LEOTONE "SPECIAL"!
PORTABLE D.C. AMMETER



0-15 Amperes
Unbeatable at this Price!
Hoyt type 515. Precision calibrated 3¼" mirror scale offers laboratory accuracy. Knife-edge pointer; 75 scale divisions. Moving coil D'Arsonval 50 MV. movement. For use in Laboratory, Radio-Electronics, Electrical work, etc. Complete with 36" clip type leads. In black wrinkle finish metal case (6¼" x 5⅜" x 2⅜") with hinged lid. GUARANTEED BRAND NEW. While they last—Only **$5.95**
6 FOR $30.00
20% DEPOSIT ON C.O.D.'s
GET ON OUR MAILING LIST
ALWAYS SOMETHING NEW
LEOTONE RADIO CO.
65 DEY ST. NEW YORK CITY

POCKET FAST EASY
EXTRA PROFITS
Selling and Installing
Autone
AUXILIARY SPEAKER





Sales will soar to new highs when you display the NEW AUTONE AUXILIARY SPEAKER. More than 25 million autoists in the United States are ready prospects! They want the full, rich "Living Room" reception that an auxiliary AUTONE will give their car radios; they want the inexpensive luxury of a rear seat, separately controlled radio speaker, the pleasant, safe convenience of complete reception at low level volume. The New AUTONE is a high quality speaker. Show it in your store with our dealer aids, and it will sell itself. Your service department, too, will reap extra profits through installations of these popular units. Easily, quickly installed. Retails at $9.95 complete with switch, cable, etc., plus installation. Long discount, big markup for you. Contact your jobber TODAY or write us direct.

NORTHERN PRODUCTS CO.
6347 N. Clark St., Chicago 26, Ill.

CORRESPONDENCE COURSES IN
RADIO and ELECTRICAL ENGINEERING

ELECTRICAL ENGINEERING Get good grasp of wide electrical field. Prepare yourself at Low Cost, for secure future. Modern course. So simplified anyone can understand quickly.

RADIO ENGINEERING Extra fine course in radio, public address, photo-electric work. Trains you to be super-service man, real vacuum-tube technician. Servicemen needed badly. Diploma on completion. Many graduates earning big pay.

WRITE Send postcard for Free Copies of school catalog full details, all about deferred payment plan, experimental kits, etc. **$25** Either Course

LINCOLN ENGINEERING SCHOOL, BOX 931-R114 LINCOLN 2, NEBR.

ATTENTION RADIO DEALERS AND SERVICEMEN!

- Are you fed up with those so-called war surplus bargains? Then call on us for standard radio parts at regular dealers discounts.

EL MONTE ELECTRONICS SUPPLY CO.
992 East Valley Blvd., El Monte, California
BUdlong 8-4228

M, as a null indicator. The reading at null (due to harmonics) is recorded. The switch is then thrown to position 1 and R_5 is adjusted until the meter gives the same reading (as before at null). The following calculation may be performed to determine the per-cent of total harmonics from this operation:

$$\%H = 100R_5/(R_4 + R_5)$$

A dial indicator attached to the potentiometer R_5 may be calibrated directly in these percentages.

(*To be continued*)

REFERENCE

*"*The Aerovox Research Worker", *Vol. 9, Nos. 6 and 7; Vol. 12, No. 7. Aerovox Corporation.*

Receiver Design

(*Continued from page 47*)

type oscillator the cathodes of the two sections are tied together or are capacitively coupled for oscillator coupling. The 7F8 and the 6J6 are the most frequently used tubes in this type of circuit. The dual-triode converter has a high input resistance and a low noise level which contributes to its popularity.

The tuning condenser is mechanically sturdy and can be tuned easily. It does rely on wiping contacts for grounding the rotor and these contacts must be kept clean and lubricated for quiet operation.

Variable Inductance Tuner

Another type of tuner is the *Meissner* variable inductance tuner. It is used in their Model 2961. The r.f., oscillator, and mixer stages are constructed on a separate chassis which is completely shielded. A side view of this tuner is shown in Fig. 1 with the side shield removed.

The antenna terminals are on top of the chassis directly over the antenna coil. The primary is a two-turn coil with the center tap connected to the chassis. This primary is closely coupled to the antenna coil. The input is matched to a balanced 300-ohm line.

The tuning is accomplished by inserting the "blades" between the turns of the coils. The coils consist of three turns of wire. There are two "blades" on each tuning section which slice between the turns. The "blades" are cam shaped and mounted off-center on the tuning shaft. In this type of tuning there is no connection required between the rotor and the coils. Each of the tuning sections is insulated from the other by an insulated section in the tuning shaft. This is to prevent feedback through the tuning shaft from the mixer to the input coil. A shield is placed between the mixer and r.f. stage to further lessen feedback.

The theory of operation of this tuner is that the insertion of the "blades" in the coils not only reduces the coupling between the coils but the "blade" itself acts as a shorted turn and further reduces the inductance. With the "blade" in the coil, inductance is at a minimum and the unit is tuned to the high frequency end of the band. This is opposite of the condenser-tuned coil for the completely meshed condenser tunes to the *low* frequency end. There is a slight increase in capacity when the "blades" are meshed. The change in capacity is very slight as compared to the change in inductance. This slight change in capacity is due in part to the wide spacing of the "blades" from the coils and also because the tuning shaft is not connected to the chassis.

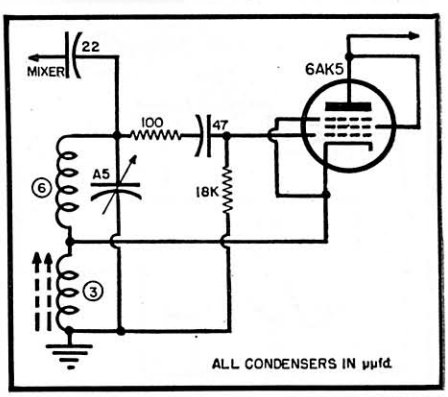
The tuning "blades" are specially designed and cut to give proper tracking. Final adjustments of tracking may be accomplished as follows: The coils are trimmed at the high frequency end with capacity trimmers. At the center of the band the center turn of the coil may be moved off its axis for tracking adjustment. At the low frequency end of the band the two outer turns are compressed or spread out, whichever is required, for proper tracking. Careful adjustment of these coils provides excellent tuner sensitivity.

The tuner uses a 6AG5 as an r.f. amplifier and another 6AG5 as a mixer. A 6C4 is used as a separate oscillator. The 6AG5 is one of the more efficient r.f. amplifier tubes at the higher frequencies. The input resistance of this tube is fairly high at *FM* frequencies and good gain is realized from the tube.

The oscillator is a hot cathode type. The oscillator voltage is coupled from the cathode of the oscillator, through a 10 mmfd. condenser to the cathode of the mixer which is 4700 ohms above ground. There is no shield between the oscillator coil and the r.f. coil which allows some inductive coupling between these coils.

Mechanically this type of tuner is simple and should be trouble-free. There are no wiping ground contacts and only two bearings. The tuning action is a rotary motion which enables coupling

Fig. 7. Method for spreading the short-wave bands of the "guillotine" tuner.



THE RECORDING and REPRODUCTION of SOUND



A commercially-built decibel meter primarily used in industry.

By OLIVER READ
Editor, RADIO NEWS

Part 17. A study of the decibel — its definition, how used, and how calculated.

THE measurement of gain in an amplifier or loss in a transmission line or attenuator circuit is usually expressed in db. (decibels) rather than in watts or volts. The reason for this is the fact that the human ear responds to intensities of sound logarithmically rather than linearly.

A sound having 10 watts of power is 10 times as loud to the ear as a sound of 1 watt and a sound of 100 watts is 10 times as loud as a sound of 10 watts but only 20 times as loud as a sound of 1 watt..

A sound of 1000 watts (1 kilowatt) is 20 times as loud as a sound of 10 watts or 30 times as loud as a sound of 1 watt. We must, therefore, use a "mental yardstick" having a logarithmic scale and not the usual rule.

The standard transmission unit is the decibel (abbreviated db.) and is equal to one-tenth of a bel. Nominally, it supersedes the *TU* (transmission unit), although specifying exactly the same thing as the latter term. The bel, named in honor of Alexander Graham Bell, was adopted by an international convention of telephone engineers.

The decibel is a logarithmic expression of a ratio between two quantities. As a unit of measurement, it specifies no definite amount of current, voltage, power, or sound but represents merely a ratio between two magnitudes. It is therefore a relative unit. Since the db. is a logarithmic unit, successive gains or losses expressed by it may be added algebraically.

The db. may express a ratio between two values of either current, voltage, power, or sound energy. It thus becomes possible to determine the db. gain for a given amplifier from ratios that express either voltage, current, or power amplification. Gain is expressed as *plus* db., loss as *minus* db.

While the decibel may show gain or loss with respect to the power at some point in a system, it properly has no regard for the finite value of any reference power. However, it is accepted practice in some radio and telephone measurements to designate the power level of 0.006 watt (6 milliwatts) as *zero* db. and to express any other value of power as a certain number of db. above or below this reference level. Hence, the expressions "db. up" and "db. down." (See table, Part 1, March, 1947, issue Page 54).

Determination of Ratios

Ratios are common to everyday scientific ratings. They express relative superiority or inferiority, gains or losses in a concise and readily understandable manner. We state that a certain transformer permits a voltage step-up of 2 to 1, etc. Such simple ratios might easily be converted into convenient statements of db. gain and db. loss.

The ratio of two values of power, for example, P_1 and P_2 is represented as:

$$P_1/P_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Or, the larger power is divided by the smaller. It is easily seen that the actual instantaneous magnitudes of P_1 and P_2 might extend over a wide range of values but would be of no concern to the quotient as long as they remained in the same proportion.

The number of decibels represented by such a ratio is obtained by multiplying the logarithm of the indicated quotient by 10:.

$$no.\ db. = 10 \log_{10} (P_1/P_2) \quad \ldots\ldots\ldots (2)$$

Observe that the common logarithm of the quotient (ratio) is employed, i.e., the logarithm to the base 10. Hence the form, $\log_{10}$. From equation (2) the following rule may be stated:

Rule A: The number of db. is numerically equal to 10 times the common logarithm of a power ratio.

Voltage and current ratios may also be expressed in terms of decibels. If the two values of voltage E_1 and E_2 are measured across the same or identical impedances, or if the two values of current (I_1 and I_2) are taken through the same or identical impedances:

no. db $= 20 \log_{10}(E_1/E_2) = 20 \log_{10}(I_1/I_2)$. .....(3)

Observe that in equation (3) the logarithm of the ratio is multiplied by 20 instead of 10. This is because power varies directly as the square of the voltage or the square of the current, and a logarithmic expression obtained in the manner of equation (2) needs to be multiplied again by 2, since doubling a logarithm is equivalent to squaring the number.

If, as is occasionally the case, the current or voltage values in the ratio are not associated with the same or identical impedances, our decibel computation must take into consideration the absolute magnitudes of the corresponding impedances and power factors of the impedances:

no. db. $= 20 \log_{10}(E_1/E_2) + 10 \log_{10}(Z_2/Z_1) + 10 \log_{10}(f_1/f_2)$ .....(4)

and

no. db $= 20 \log_{10}(I_1/I_2) + 10 \log_{10}(Z_1/Z_2) + 10 \log_{10}(f_1/f_2)$ .....(5)

Z_1 and Z_2 are the impedances in which the voltages and currents operate, and f_1 and f_2 are the values of the corresponding power factors of the impedances.

From equations (3), (4), and (5) the following rules may be stated:

Rule B: When a voltage or current ratio shows values associated with the same or identical impedances, the number of db. is numerically equal to 20 times the common logarithm of the ratio.

Rule C: When a voltage ratio shows values associated with unequal impedances, the number of db. is numerically equal to a sum of three logarithmic expressions: 20 times the log of the voltage ratio plus 10 times the log of the impedance ratio plus 10 times the log of the power factor ratio.

Rule D: When a current ratio shows values associated with unequal impedances, the number of db. is numerically equal to the sum of three logarithmic expressions; 20 times the log of the current ratio plus 10 times the log of the impedance ratio plus 10 times the log of the power factor ratio.

Relationships

By definition, the common logarithm of a number is the exponent denoting the power to which 10 must be raised to equal the given number. Thus, 3 is the common log of 1000 since 10 must be raised to the third power to equal 1000. 5 is the common log of 100,000; 6 of 1,000,000.

Column 2 of Table 1 lists common logs corresponding to a few of the even-numbered ratios frequently encountered in radio work. The ratios are given in column 1. These logs are multiplied by 10 (in column 3) to give db. for power ratios, and by 20 (in column 4) to give decibels for current or voltage ratios.

It is readily seen from the chart that a power ratio of 100 to 1 corresponds to 20 db., while a current or voltage ratio of the same magnitude corresponds to 40 db. A ratio of 1,000,000 is equivalent to 60 db. for power, but 120 db. for current or voltage. It is also seen that a power, voltage, or current ratio must be squared in order to double the number of decibels; and that increasing a power ratio to 10 times its original value is equivalent to adding 10 db., while the same increase in a current or voltage ratio is equivalent to adding 20 db.

It should be apparent to the reader that the same number of db. may be obtained from each of a number of ratios with widely divergent numerator and denominator values, as long as the same proportion exists between the two terms. A clear understanding of this condition not only explains why an extremely low-powered system can show the same number of db. gain as one of high power, but at the same time also places illustrative emphasis upon the relativity of the transmission unit.

Consider, for example, three a.f. amplifiers—one delivering 1 watt output with 0.1 milliwatt input; the second delivering 10 volts output for 100 millivolts input, both input and output circuits operating into 500 ohms impedance; and the third delivering 50 watts output for 5 milliwatts input. The gain in each case is 40 db.

Applications

1. *Amplifier Power Gain or Loss.* (a) Measure a.f. or r.f. input watts, (b) measure a.f. or r.f. output watts, (c) apply equation (2) and *Rule A.*

2. *Amplifier Voltage Gain or Loss.* Input and Output Impedances Equal. (a) Measure a.f. or r.f. input voltage, (b) measure a.f. or r.f. output voltage, (c) apply voltage equation (3) and *Rule B.*

3. *Amplifier Current Gain or Loss.* Input and Output Impedances Equal. (a) Measure a.f. or r.f. input current, (b) measure a.f. or r.f. output current, (c) apply current equation (3) and *Rule B.*

4. *Amplifier Current or Voltage Gain or Loss.* Unequal Input and Output Impedances. (a) Measure a.f. or r.f. input voltage or current, (b) measure a.f. or r.f. output voltage or current, (c) determine absolute values of input and output impedances, (d) determine absolute values of power factor for the two impedances, (e) apply voltage equation (4) and *Rule C* or current equation (5) and *Rule D.*

Note:—Any of the foregoing amplifier characteristics may be taken for the entire amplifier (over-all), a single stage (per stage) or any cascaded group of stages. A *plus db.* rating indicates gain; *minus db.*, loss.

5. *Amplifier Output Level, or A. F. Line Level.* This is stated by engineers and manufacturers as so many db., the number of decibels above or below 6 milliwatts (zero db.) being assumed. Apply the equation:

$$P \text{ in watts} = .006 \times \text{antilog}\ (\text{db.}/10) \quad \ldots\ldots(6)$$

The term db. is the figure stated for amplifier or line. An *antilog* is the figure or number which corresponds to a certain log. (Looking up an antilog in the log tables is the reverse of the process of looking up a log.)

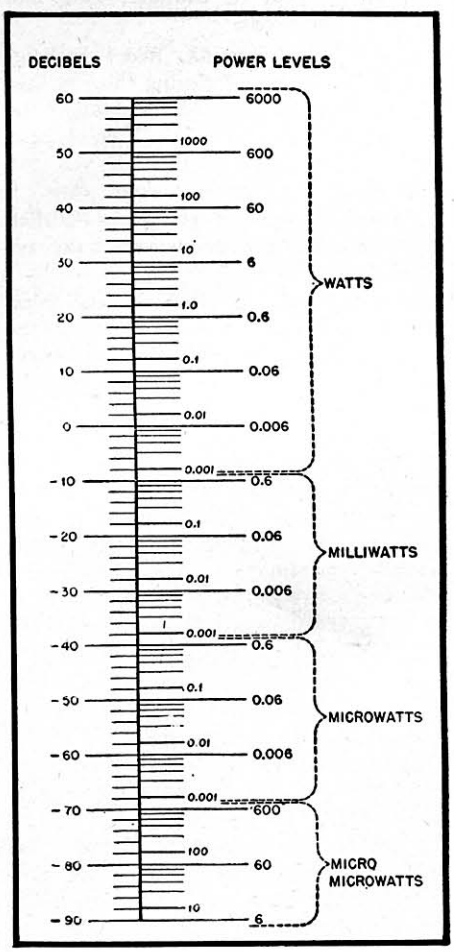
6. *Microphone, Hum, Input Signal or Noise Level.* This is generally stated as so many negative db., or "db. down," and like Example 5 refers to zero db.

(Continued on page 125)

(1) RATIO	(2) LOG OF RATIO	(3) DB FOR POWER RATIO	(4) DB FOR CURRENT OR VOLTAGE RATIO
1	0	0	0
10	1	10	20
100	2	20	40
1000	3	30	60
10,000	4	40	80
100,000	5	50	100
1,000,000	6	60	120

Table 1. Relationship between voltage, current, and power ratios and decibels.

Table 2. Chart showing the relationship between watts and decibels based on the standard zero level of six milliwatts.



gram of the compensating network is available on request from *Lear Incorporated,* 110 Ionia Avenue, N.W., Grand Rapids 2, Michigan. —30—

Recording of Sound

(Continued from page 53)

as 6 milliwatts. Since we are dealing with ratios only, we can work out the problem assuming a positive db. level to get the power ratio, then divide the reference level, 6 milliwatts, by this ratio to get the actual level. For example, a level of —19 db. will be assumed for the purposes of calculation. Taking the antilog of (19/10) or 1.9 gives 79.4. The actual power level represented by —19 db. would then be .006 divided by 79.4 or .000076 watts, or .076 milliwatts. This method simplifies calculation somewhat as it avoids the necessity of dealing with negative logarithms.

Use of the Slide Rule

Problems involving decibels are easily solved on the slide rule, making use of the *L* logarithm scale. Converting a power ratio to decibels is accomplished by setting the indicator to the power ratio on the *D* scale and reading the number of db. on the *L* scale. Example: the power ratio corresponding to 5 is 6.99 db. When the power ratio is higher then 10, divide by 10, 100, etc. until the quotient is less than 10. Find the corresponding db. and add 10 decibels for each place the decimal point had to be moved in order to bring the ratio within the range 1-10. Example: What is the db. gain corresponding to a power gain of 5530? Moving the decimal point three places to the left, we obtain 5.53. Set the indicator to 5.53 on the *D* scale and read 7.42 on *L*. Add 30 db. to the result, which gives 37.42 db.

If the power ratio is less than 1, the *CI* and *L* scales should be employed. Finding the db. gain corresponding to voltage ratios—if the impedances and power factors are the same in each case—proceed as described in the foregoing but multiply the result by 2.

The "log-log" slide rule offers an alternative method of finding decibels. Set the index on the slide to 10 on LL_3. Opposite the power ratio on LL_2 and LL_3 find the gain in db. on *C*. If the power ratio was greater than 10, all values found on *C* are between 10 and 100. It it was less than 10, the *C* scale may be read directly.

Finding decibels from the voltage ratio is accomplished by setting 2 on the *C* scale to 10 on LL_3. Opposite the voltage ratio on LL_2 or LL_3, the db. may be read on *C*. If the voltage or current ratio is between 1 and *pi*, the db. gain is between 1 and 10. If the



as convenient to use as a fountain-pen desk-set

TURNER MODEL 35X

Fireball

CRYSTAL DESK MICROPHONE WITH INSTANTLY DETACHABLE BASE

HANDSOME and handy . . . and low priced too! It's a desk mike, it's a hand mike. The Turner Model 35X brings high convenience to amateur communications, home recording, paging and call systems. A quarter-turn releases handle from base or locks it securely. Turner precision engineering assures smooth response to both voice and music pickups. Complete unit includes microphone with handle, base, and 7 ft. cable. Ask for Bulletin. Sent on request.

THE TURNER COMPANY

900 17th Street N.E. Cedar Rapids, Iowa

SPECIFICATIONS

- Response — 70 to 7000 c.p.s.
- Level — 52 db below 1 volt/dyne/sq. cm.
- Moisture proof crystal
- Semi-directional
- Corrosive-resistant dural diaphragm
- Blast and mechanical shock proofed
- Weighs 1½ pounds complete

List $13.25



TURNER

Licensed under patents of the Brush Development Company

HERBACH & RADEMAN

presents

OUTSTANDING VALUES FROM THE PAGES OF

"THIS MONTH"

Shown here are just a few of the hundreds of values listed every month in our bulletin "THIS MONTH". In "THIS MONTH" we bring you the outstanding "buys" from the surplus market as well as an up-to-the-minute listing of new products, gadgets and devices from scores of nationally known manufacturers. In effect "THIS MONTH" is a perpetual radio and electronic-parts guide.

RADIO NEWS READERS are invited to be put on our mailing list — free — by merely filling out the coupon below.

ALNICO MAGNETRON MAGNETS



Horseshoe shaped magnet, originally designed for use in microwave radar equipment. Field strength 4800-4900 gauss. Size 5¼" W. x 5½" H. x 2" thick. Mts. on base 3" x 2¼". Airgap 19/32". Wht.—8 lbs. Lifts more than 5 times its own weight. With Keeper. No. RN-1056..... **$4.95**

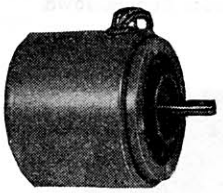
PRECISION APPARATUS 844P VOLT-OHM-MILLIAMMETER

All purpose AC-DC Multimeter in hardwood hinged cover case with a 4⅝" 1000 ohm per volt meter.

RANGES

AC and DC Volts 0/12/60/300/600/1200/6000
Milliamperes D.C. 0/1.2/12/300/600/1200
Amperes D.C. 0/12
Ohms 0/400/100,000/1 meg/10meg
Decibels 6 Ranges from - 12 to/ 70 D.B.
Output Volts 0/12/60/300/600/1200/6000
Case has tool compartment. With test leads less batteries. (Batteries $1.40 additional)
Regular Price $34.20.
No. RN-844P **$24.95**

REVERSIBLE MOTOR



Built like a fine watch. Continuous duty 1/50 H.P. Capacitor start reversible motor for operation on 115V. 60 cycle. Speed 3300 r.p.m. Size 3¼" x 3¼". Shaft 5/16" diam. x 1-3/16" long.
With capacitor.
No. RN-1002 ..... **$7.95**

ALL METAL SPEAKER BAFFLE

Enclosed all metal, sloping front, black crackle finish wall baffle. Takes a 12" speaker. Front entirely hinged. 14"H.x14"W.x9"D. Wht.—16 lbs.
No. RN4TH **$2.95**

NO SUPERLATIVES

No, we're not "the biggest," "the oldest" nor "the greatest" parts house in the world; we do guarantee complete satisfaction on every purchase. We also guarantee speedy delivery on all orders. Order direct from the page and be sure you send us your name for our mailing list. Quantities Limited. Minimum order $2.00.

Terms 20% deposit, balance C.O.D.
All prices are quoted F. O. B. warehouse Phila., Pa.

HERBACH & RADEMAN, Inc.

Electronics Specialists

522 MARKET ST., PHILADELPHIA 6, PA.

Yes indeed, send me your monthly Bulletins.

Name .....

Address .....

City..... Zone.... State.....

ratio exceeded 3.14, multiply the *C* indication by 10.

When converting power ratios less than 1 to decibels, set 1 (middle of *B* scale) to 0.10 on the *LLO* scale. The loss is then found on *B* opposite the power ratio on *LLO*. For current or voltage ratios, set 2 on the *B* scale to 0.10 on the *LLO* scale and proceed as before.

To find the gain in db. directly from two values of current, voltage, or power, set the larger of the two on *C* to the smaller on *D*. Opposite the index of *C*, find db. on *L*.

Ready-Reference Charts

For the reader's convenience, two charts have been made up from calculations involving equations (2), (3), and (6).

By referring to Table 2, the number of decibels corresponding to any power level between 6 micromicrowatts and 6 kilowatts may be found quickly, the necessity for performing equation (6) computations being eliminated in most practical instances. From Table 3, the number of decibels corresponding to any current, voltage, or power ratio may be quickly located.

Particular notice should be taken of the subdivisions in the power column of Table 2. These graduations are uniformly spaced (as regards numerical value) except that the lowermost subdivision in each power group has not the same value as each of the upper five in the group. For this reason, we have numbered the lowermost subdivision in each group. Thus, the numbered line, 10 micromicrowatts is only 4 micromicrowatts removed from the 6 micromicrowatt major division, while each other subdivision up to 60 micromicrowatts is exactly 10 micromicrowatts higher than the previous one. Thus, we read, 10, 20, 30, 40, and 50 micromicrowatts between 6 and 60 micromicrowatts. Similarly, we read, 100, 200, 300, 400 and 500 micromicrowatts in the next highest power group, between 60 and 600 micromicrowatts.

To illustrate the use of Table 2, locate the db. output rating of a 6L6 amplifier, the audio output of which is 60 watts. Opposite the 60 watt line in the power column will be found the 40 line in the decibel column. On the basis of 6 milliwatts as zero db., a power level of 60 watts is 40 db.

The power output of a high quality microphone rated at minus 45 db. may be found in the same manner. Read 0.2 microwatt directly opposite the "minus 45 db." in Table 2.

A current, voltage, or power ratio is located in the ratio column of Table 3 and the number of decibels read directly opposite in the power column or current-voltage column, depending upon

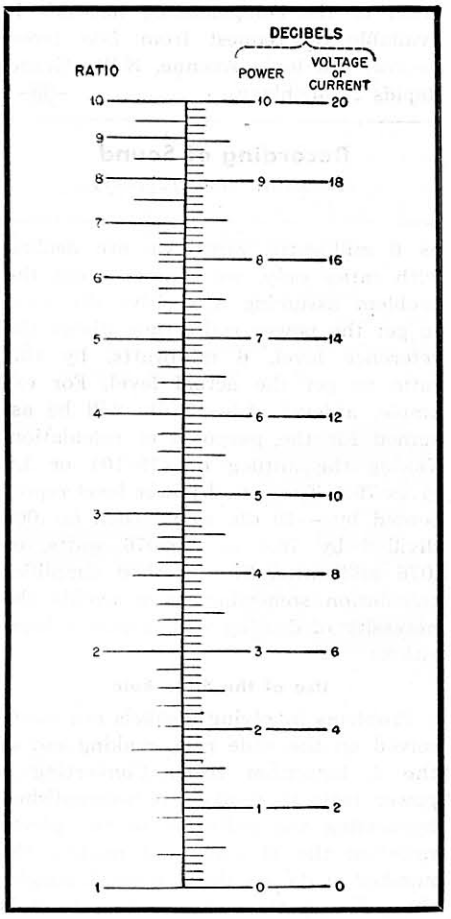


Table 3. The number of decibels corresponding to any voltage, current, or power ratio between the values one and ten.

the nature of the ratio. For example: a power ratio of 4 is seen to correspond to 6 db. while a current or voltage ratio of the same value equals 12 db.

The use of Table 3 can be extended beyond the current or voltage ratio of 10 by adding 20 db. for each place the decimal point has been moved to the right to make the figures in the ratio column correspond to those in the ratio desired. For example: to find the db. equivalent to a current or voltage ratio of 44, locate 4.4 in the ratio column of Table 3. Read the equivalent 12.8 db. in the current-voltage db. column. The decimal point was moved one place in 4.4 to convert it into the ratio, 44. Therefore, add 20 db. to the result. 12.8 plus 20 equals 32.8 db.

The use of Table 3 may similarly be extended beyond the power ratio of 10 by adding 10 db. for each place the decimal point is moved to the right. For example: look up the power ratio 160 as 1.6 in the ratio column. This would correspond to 2 db. But the decimal point was shifted two places to change 1.6 to 160 and 10 db. must be added for each place. The result, therefore, is 2 plus 20, or 22 db.

Reference

The Aerovox Research Worker, Vol 13, No. 7; July, 1941

(To be continued)

The RECORDING and REPRODUCTION of SOUND



Fig. 1. RCA accordion cone, 7-inch permanent magnet speaker.

By
OLIVER READ
Editor, RADIO NEWS

Part 18. A discussion of factors influencing behavior of reproducers at audio frequencies.

IT is unfortunate that so many personal prejudices and economic considerations enter into current discussions of high fidelity. If a group of people are asked to express their preference, the comparison should be presented to them in terms of "live" music (which true high fidelity would simulate indistinguishably) as opposed to low fidelity reproduction. Music appreciation is largely a matter of conditioned reflexes. There is a distinct danger in current trends to dull the senses and limit measurably the scope of tonal appreciation in future generations. Furthermore, the willingness of the public to pay for high quality reproduction is underestimated. The term "high fidelity" has been so misused as to almost destroy its value.

Modern designing knowledge makes it possible to produce vacuum tube devices with almost any desired frequency response. With suitable filter networks, it is not difficult to compensate electrically for the response curve of the ear at different intensity levels, as well as for frequency range limitations in broadcast and recording practice. But the variation with frequency in sound pressure from a loudspeaker is too violent to be disposed of practically in this manner. The point is that the selection and design of loudspeakers and associated enclosures probably deserve more contemporary engineering attention than any other field of associated development. The difference in the quality of the end result when a really good loudspeaker system is substituted for the reproducer in an average home radio is greater than even most technicians in the industry realize.

Speaker Placement

Innumerable texts and common knowledge dictate the intelligent placement of loudspeakers in most large installations. Strangely, although the experimental facts have been widely published, optimum placement of speakers in homes and small rooms is rare. This ideal position is in a corner, preferably at the floor or ceiling junction with the walls. This location has been shown to produce three or four times as much radiation of low frequency energy as mid-wall placement. Where semi-permanent special enclosures may be constructed, a triangular cabinet or close fitting flat baffle fitting the corner from floor to ceiling is desirable. However, simply moving a standard console radio to form a hypotenuse across the corner of a room results immediately in a noticeable improvement in low frequency radiation.

Enclosures

Completely enclosed cabinets eliminate cancellation of low frequencies from the interaction of front and backside radiation. However, the natural frequency of the speaker will be effectively dependent on the compliance of the enclosed volume of air, thus varying with the cabinet size. The use of absorptive material aids in lowering the resonant frequency of the system. The installation of a speaker in the wall between two rooms represents the extreme (and ideal) condition for complete enclosure.

Labyrinth type cabinets, which may or may not be of semi-exponential design, are usually lined with absorptive material to eliminate high frequency distortion from interacting radiation between the speaker cone and labyrinth mouth. Reinforcement in a limited range of middle low frequencies is obtained by the phase shift resulting from the transmission time delay of the back wave through the labyrinth. This effect is greatest when the labyrinth is a ¼ wavelength and functions as a mechanical counterpart for a ¼ wavelength tuning stub with respect to impedance relationships. When radiation from the labyrinth mouth is maximum, the speaker diaphragm looks into a high impedance and is highly damped. At very low frequencies the phase shift may be practically eliminated and cancellation will take place.

Bass reflex speaker enclosures have gained increasing popularity because of the excellent results obtained. The theory of their design is interesting and not too widely understood. Absorptive material is used in these cabinets to eliminate high frequency radiation from the reflex opening. Incidentally, it is worthy of note that the absorption coefficients in published tables for acoustic materials at the lower frequencies indicate negligible absorption in this range. The cabinet is usually designed in a dimensional relationship that avoids air column resonance; it need not be as large as either a complete enclosure or labyrinth type to achieve comparable results.

An ideal speaker diaphragm would



Fig. 2. The Jensen dual-unit coaxial loudspeaker suitable for large installations.

Fig. 3. Altec Lansing multicell "Diacone" speaker.

have minimum inertia, and minimum distortion from flexure and centering cone edge supports. The cross section of air in the opening of a reflex cabinet is effectively such an idealized diaphragm. The speaker cone is coupled to the opening through the elasticity of the enclosed air in the cabinet.

The reflex opening is deliberately made large and placed close to the speaker cone. Within a relatively broad range above and below a specific low frequency, the coupling will be such as to highly damp the speaker cone and produce the major portion of radiation from the virtual source represented by the reflex opening. There is no time delay involved in producing this phase shift. It results from the equivalent *L-R-C* circuit of the coupling medium, the speaker cone, and the reflex opening. It is clear that at some frequency in the lower ranges the coupling will lag by 180 degrees as a result of the compliance of the coupling medium. Since the virtual diaphragm is effectively undamped at this time, its swing will greatly exceed the amplitude of the speaker cone. This means not only that the radiated energy will be increased in this frequency range, but also that the undistorted conditions of the idealized virtual diaphragm of the reflex opening will be realized at maximum efficiency.

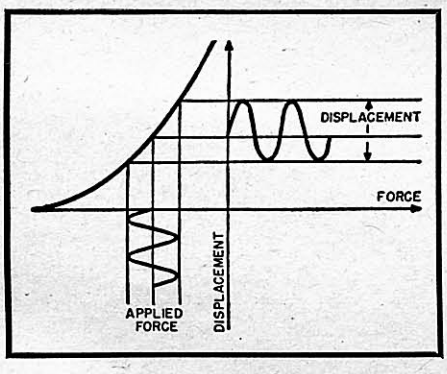


Fig. 4. Characteristic curves showing result of non-linear relationship between front and back radiation impedance.

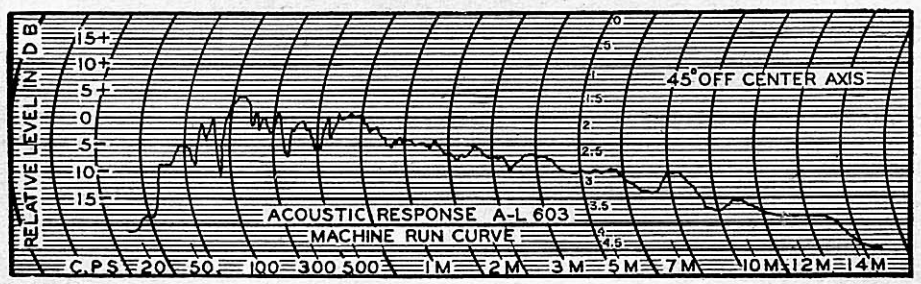
Bass reflex cabinets may be designed haphazardly (as they often are) with the probability of improving the response of a speaker selected at random. However, to achieve anything approaching the full advantages available from such enclosures, they should be devised in terms of the characteristics of a specific loudspeaker.

Many shapes of loudspeaker cones have been developed experimentally, but the most efficient and satisfactory design is circular. Elliptical cones were early abandoned because of problems in mechanical structure and other disadvantages. Although flared cone sides are not as strong for a given weight as straight sides, the response is appreciably improved above 5000 c.p.s. However, in speakers designed primarily for high power handling capacity and moderate frequency response, straight sides are used almost exclusively.

Most cones are made of specially fabricated papers. Where efficiency in quantitative transfer of energy is important at the expense of smooth response, very hard papers are used. More flexible structures are selected for high quality reproduction. A compromise is sometimes made between mechanical strength and smooth response by closely spaced annular rings in which the fibrous structure is deliberately broken down. Very soft material similar to blotting paper may be used to smooth the response and eliminate sharp dips and peaks still further in the response curve, but high frequency response is sacrificed. Another compromise is achieved in polyfibrous cone types where as many as three different degrees of hardness are used in the construction of a single cone. The cone is usually divided into three bands of approximately equal width with the material becoming softer and increasingly fibrous away from the voice coil.

One of the most interesting developments is the so-called "accordion cone" speaker, Fig. 1. Here the outer edge of the cone floats without contact to the metal structure, and a supporting structure of cone material is folded back accordion-wise to provide centering. This small speaker has an exceptionally smooth response and an extended frequency range that covers from 80 to 7000 cycles-per-second with excellent fidelity, tapering off to 30 cycles down and 14,000 cycles upward. This type of folded edge cone support extends the lower frequency limit at least one octave below that obtainable with conventional construction for the same unit. The amplitude of piston swing at low-level low frequencies is a contributing factor in the effective transducing efficiency of the unit. Four of these speakers in a suitable cabinet will handle twelve watts complex wave, and are difficult for the most critical listener to distinguish from systems costing ten times as much. There appears to be no reason why this principle cannot be applied to speakers of larger cone diameter with equally desirable results. It is suggested that similar results might be obtained perhaps with better acoustic loading by folding the edge of the speaker cone forward to its support when physical depth is not a factor.

Fig. 5. Curve of acoustic response for the Altec Lansing Model 603 shown in Fig. 3.



Dual Combinations

There are many reasons why it is not practical to cover the entire audible frequency range with a single transducer.

Among these is the fact that mechanical and electrical impedances vary with frequency, and it is clear that the wider the frequency range, the more difficult it is to provide an approximate match throughout. It is also true that a desirable directional characteristic over a wide frequency spectrum is incompatible with contemporary fundamentals of design. In order to obtain the most efficient transfer of energy, particularly at low levels where mechanical damping is effectively high, it is common practice to use a speaker of a large cone diameter for low frequencies.

At high levels this is also necessary in order that the cone may be free to swing over the required amplitudes at low frequencies. There are other considerations involved in this requirement, but directivity at low frequencies is not a problem. At high frequencies, where the tendency to beam becomes pronounced, it is of great importance that the diameter of the source be small compared with the wavelength of the sound energy. Contrary to what might be expected at first consideration, the angle of directivity varies inversely with the physical size of the sound source when compared with the wavelength. Thus a large speaker cone, or large horn mouth acting as a virtual source, decreases the angle of distribution at high frequencies. Where an effort is made to design a single unit to cover an excessively wide frequency range, the distortion caused by transients and cross modulation effects from various modes of vibration at the extremes of the spectrum is greatly increased.

It is of practical value to note that multiple speakers of identical response characteristics may be used to advantage in extending the low frequency range of a system. Although the total cost may be somewhat increased, it is sometimes more economical to use several relatively low cost speakers than a single more expensive one. These may be installed in a single cabinet with the desired result of extending the low frequency response more than might be achieved with a single unit of high cost. This practice will almost invariably increase the power handling capability of systems of comparable cost. It is also true that spatial distribution of the source within an extension of six to ten feet is considered pleasing by most listeners, even in relatively small rooms. Obviously, placing these speakers at different angles will improve the dispersion of high frequencies.

Where dual speakers are used to cover high and low frequency ranges respectively, it is usually desirable to use an electrical dividing network to channel each section of the spectrum to its corresponding speaker. It is sometimes possible to simplify this network with carefully selected speakers and permit the ranges to overlap considerably. In such instances it is only necessary to eliminate the very low frequencies from the high channel because of power handling considerations. However, the design of frequency dividing networks is relatively simple and the optimum arrangement is more easily achieved electrically than acoustically. The point of crossover may vary considerably, but commercial networks are generally designed to divide in the region between 500 and 1000 cycles-per-second.

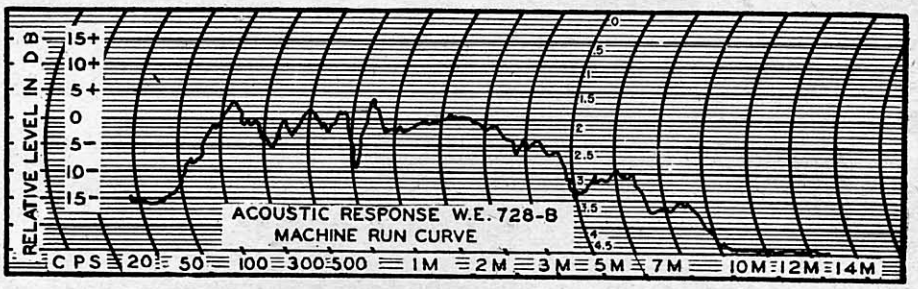


Fig. 6. Acoustic response curve for the Western Electric Model 728-B (Fig. 8, left).

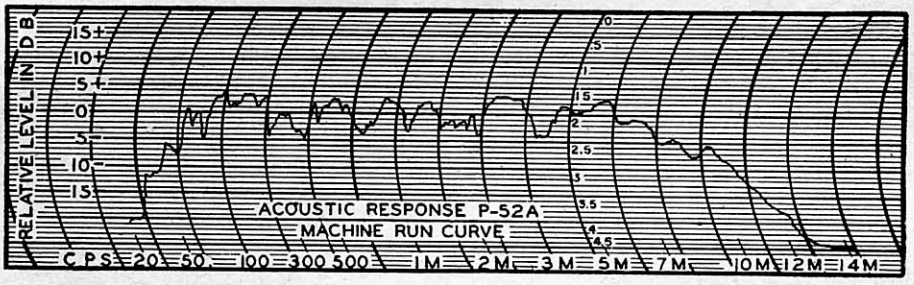


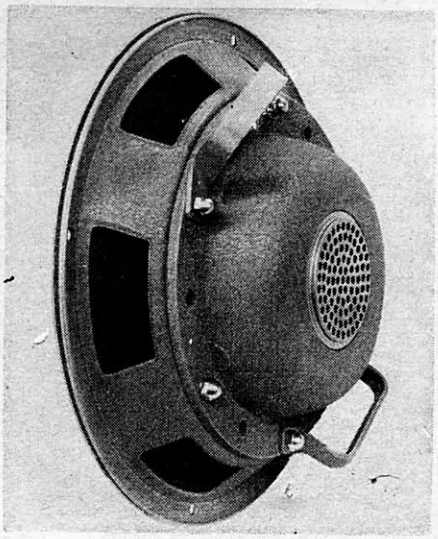
Fig. 7. Acoustic response curve for the Tru-Sonic Model P-52A shown in Fig. 8, right.

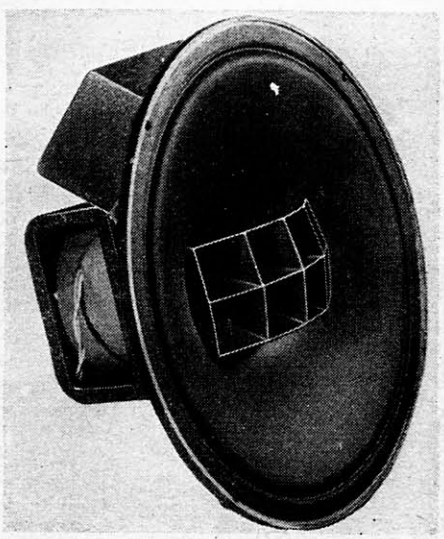
While large installations usually involve low frequency speakers fed into folded horns and high frequency driving units acoustically coupled through honeycombed projectors, the recent development of dual speakers for home installations or other moderate power requirements favors coaxial mounting of two units (Fig. 2). This arrangement is mechanically convenient but appears to contribute little to the acoustic properties of the system. However, it is of importance to note that dual speaker arrangements require the coordinated design of each unit in order to obtain optimum results. It is possible to improve the range of a single large diameter speaker with the addition of a high frequency speaker and suitable dividing network, but it is fallacious to assume that a small cone diameter implies good high frequency response. In the smaller units it is generally worthwhile to supplement the usual cabinet enclosure with shutters placed over the high frequency opening so as to improve the spatial distribution. One manufacturer uses a small coaxial mounted multicellular horn for the dispersion of high frequencies, even in relatively low power handling units (Fig. 3).

In connection with honeycomb horns, an interesting aspect of elliptically shaped speaker cones and rectangular horn mouths is often important. There is a widespread misconception regarding the angle of distribution achieved in terms of placement of the long axis. Actually the widest horizontal distribution angle is obtained when the long axis is placed vertically. Although this phenomenon is minimized by radial curvature of the horn mouths, the distribution may sometimes be improved

(Continued on page 143)

Fig. 8. (Left) The Western Electric Model 728-B speaker. (Right) The Tru-Sonic Model P-52A coaxial speaker. This small, two-way sound reproducing assembly allows a vertical sound distribution of 40 degrees and horizontal distribution of 80 degrees.





by reducing this curvature along the axis and placing it in a vertical position. This is particularly true in rectangular horns that are not subdivided, but the effect is obtained at frequencies around 400 c.p.s. even in the case of multicellular designs. This result might be theoretically developed from the previously mentioned inverse relationship between the diameter of the sound source and the magnitude of the distribution angle.

It has been said that response curve compensation is relatively easy to achieve electrically, but this does not mean that there is no available method for accomplishing such results acoustically. In radio receivers the response is often characterized by a "boomy" quality caused by the resonant frequency of the cabinet in which the speaker is housed. This occurs when the resonant frequency of the air column in the enclosure falls in the lower audible range. Thus whenever the sound generated approaches this frequency, the air column is set into vibration and becomes a virtual source providing physical amplification. In engineering practice, it is almost always true that a disadvantage in one context can be turned to good account if properly applied. This phenomenon provides an excellent example.

Physical resonance resulting in effective amplification is a common effect. Whenever a sound is generated in the presence of a column of air at its resonant frequency, there will be a more efficient transfer of energy into the surrounding medium than at other frequencies. Thus, in an idealized case, if the response of a speaker were perfectly flat over the entire audible range except for a dip at one specific frequency, this fault could be compensated within limits by placing an "organ" pipe of the correct frequency in the vicinity of the speaker. Clearly this principle is capable of extension to correct the response at an indefinite number of frequencies. Resonators of this kind have been developed successfully. Designing such an installation to correct all of the faults in a loudspeaker response curve is beyond the realm of practicality. However, it is entirely feasible to install resonators in loudspeaker enclosures in such a manner as to "brighten" the high frequency response with excellent effect. Commercially this involves too great a cost for widespread application, but in specific installations the experimenter may be rewarded with interesting and remarkable results.

1. The term "blocked impedance" is used to describe the impedance measured with the speaker cone held immovable.

2. "Radiation impedance" is the increase in impedance caused by the effect of the transmitting medium on the vibrating surfaces. The terms "radiation resistance" and "radiation mass" (the reactance is generally positive), are the rectangular components.

3. The "Force Factor" of a speaker is

PROGRESSIVE

NOW! BUILD 15 RADIOS $14.75
COMPLETE KIT ONLY...

ABSOLUTELY NO KNOWLEDGE OF RADIO NECESSARY
YOU NEED NO ADDITIONAL PARTS!

THE PROGRESSIVE RADIO KIT is the ONLY COMPLETE KIT

Operates on 110-120 volts AC/DC. Contains everything you need. Instruction Book, Metal Chassis, Tubes, Condensers, Resistors and all other necessary radio parts. The 36-page Instruction Book written by expert radio instructors and engineers teaches you to build radios in a professional manner. The first circuit built is a simple one-tube detector receiver. Each succeeding circuit incorporates new arrangements of detectors, RF and AF amplifiers. This kit is excellent for learning the principles of receiver, transmitter and amplifier design. It is used in many radio schools and colleges. All of the commonly-used detectors are used, including diode, grid leak, plate and infinite-impedance. The transmitters are designed with Hartley and Armstrong oscillators, using screen-grid and control-grid modulation. Both vacuum tube and selenium rectification are employed in these circuits. The circuits are designed to provide excellent performance. Altogether, fifteen circuits are constructed, including 11 receivers, 1 audio amplifier, and 3 transmitters. The sets start with simple circuits of 1 tube plus rectifier, gradually grow more complex, and finish with several examples of radio sets using three tubes plus rectifier.

PROGRESSIVE RADIO KIT . . . ONLY $14.75

SPECIAL FREE OFFER

Electrical and Radio Tester sent absolutely FREE with each Progressive Radio Kit. PLUS FREE membership in Progressive Radio Club. Entitles you to free expert advice and consultation service with licensed radio technicians. Write for further information or ORDER your KIT NOW!



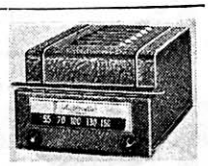
The Hottest Combination in Years!
TOM THUMB CAMERA-RADIO Combination!

It's here . . . the Cameradio, indispensable for trips, hikes, ball games, every outdoor and vacation activity. Combines a fine Reflex Camera and a powerful Radio into one easy-to-carry unit. Order now . . . you'll double the enjoyment of every weekend!

- Precision Built
- Excellent Tone Quality
- Full Vision Slide-Rule Dial
- The Ideal Vacation Companion
- Portable Radio Battery Operated
- Reflex Camera, Standard #127 Films

ONLY $28.75 Less Batteries

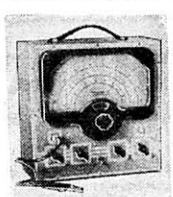
Automatic AUTO RADIO



Tops in car radios, now at a new low price! Six-tube superheterodyne with steady, full-toned reception. Mounting brackets included for easy installation in your car. Don't miss this big bargain!

- Six Tube Superheterodyne
- Three Gang Condenser
- Powerful Long Distance Reception
- Fits All Cars, Easy Installation
- Mounting Brackets Included

Only $29.97



EICO MODEL 315
SIGNAL GENERATOR
with micro-cycle band spread vernier tuning

Vitally important for tuning and aligning FM and Television receivers where tuning is very sharp and critical. The extreme wide range and accuracy afforded by the microcycle vernier band spread dial assures accurate frequency adjustment for test or alignment of broadcast FM or Television receivers. Vernier dial divided into 100 divisions. Any frequency can be tuned and repeated within .02% accuracy. Spring loaded split gears eliminate back lash and play providing smooth accurate tuning. Window casing encloses and protects the lighted dial and its fine pointer from accidents and jarring out of calibration. Range 75 KC to 150 MC ★ Complete broadcast band from 550 KC to 1700 KC covered on one range without switching ★ Unused coils are automatically shorted out to eliminate dead spots and absorption ★ Linear dial calibration. DOES NOT CROWD-UP on high frequency end of dial ★ Accuracy better than .5% throughout the broadcast band and 1% on the higher frequencies ★ Just as accurate at high end of dial as at low end..... $64.50

VACUUM TUBE VOLTMETER



MODEL 221

A completely new and different vacuum tube voltmeter at an unusually low price. Its amazing performance sets standards of accuracy, linearity, and stability not usually found in this type of instrument. Electronic AC ranges is more linear and accurate than was ever possible with a copper oxide rectifier. Completely electronic so meter can not be burned out. AC and DC ranges: 0-5, 10, 100, 500 and 1000 volts. Ohmmeter measures from .2 ohm to 1,000 megohms in 5 ranges. Each instrument is individually calibrated. $49.95

WRITE FOR CATALOGUE DEALERS
PROGRESSIVE ELECTRONICS CO.
Dept. RN-12 497 UNION AVE. BROOKLYN 11, NEW YORK
We pay Postage on Prepaid Orders. All C.O.D. Orders Shipped Collect.



TIMERS $2.95!!
Cramer timer with Veeder counter in hours and 1/10 hours to 9999.9. 110v. 60 cycle, a.c. 1 Diameter.

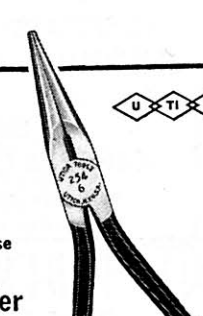
DM 35 only $2.95
NEW BOXED. This is dynamotor for BC 604, 684, etc. 12v input 625v @ 225 mils output.

BC 312 RECEIVERS
Special $54.50

GN 45 Replaces PE 103
Externally driven generator, output 6v @ 3A and 500v @ 140 mils for BC 654 and others, $6.45. Many other items. 25% cash with order. Balance C.O.D.

EMMONS RADIO SUPPLY
405 - 10th STREET OAKLAND, CALIF.
Phone TWinoaks 3-9103

UTICA TOOLS
PLIERS FOR EVERY NEED



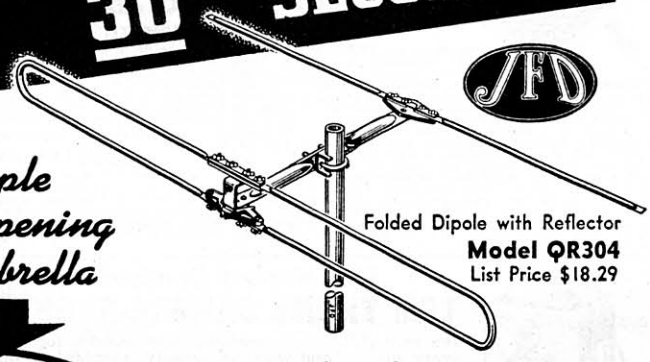
TOOL No. 254—6½"
Utica Lubring Long-Nose Side-Cutting Pliers

Ask Your Dealer

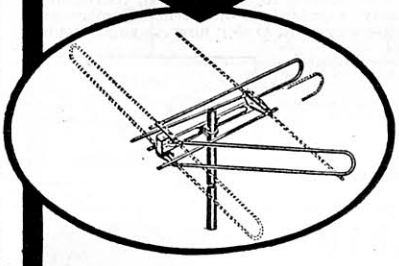
UTICA DROP FORGE & TOOL CORP.
UTICA 4, NEW YORK

THE FASTEST TV ANTENNA ASSEMBLY

YOU + JFD "QUIK-RIG" = 30 SECONDS!



As Simple As Opening An Umbrella



Folded Dipole with Reflector
Model QR304
List Price $18.29

★ The simplest— fastest— easiest antenna assembly on the market today!
★ Completely pre-assembled.
★ No special tools or knowledge required.
★ Cuts installation time to the bone.

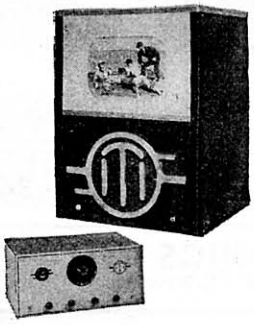
JFD Super-Beam Quik-Rig Antennas are available in a wide range of models to fit all requirements. Write for complete Quik-Rig catalog.

Ask your jobber to show you the new JFD Quik-Rig Antenna line.

JFD MANUFACTURING CO. Inc.

4109 FT. HAMILTON PARKWAY, BROOKLYN 19, N. Y.

Industrial Teleceivers



For Public Viewing in
TAVERNS - HOTELS
HOSPITALS - SCHOOLS
INSTITUTIONS - CLUBS
Featuring SIMPLIFIED CENTRAL CONTROL
with any number of viewing screens

INDUSTRIAL TELEVISION, INC.
359 LEXINGTON AVE., CLIFTON, N. J. · GREGORY 3-0900

RADIO TUBES

For immediate shipment
R.M.A. Guaranteed
Individually Sealed Cartons

GT Types		Miniature Types	
6K6GT	.40	1S5	.50
6K5GT	.46	1T4	.55
6V6GT	.46	1R5	.55
6SA7GT	.46	3S4	.55
6SJ7GT	.46	6BA6	.50
6SK7GT	.46	6BE6	.50
6SQ7GT	.46	6AT6	.42
6X5GT	.40	12BA6	.50
12SA7GT	.46	12BE6	.50
12SQ7GT	.46	12AT6	.42
12SK7GT	.46	35W4	.42
12SJ7GT	.46	50B5	.55
35L6GT	.40		
35Z5GT	.32		
50L6GT	.46		

25% DEPOSIT REQUIRED ON C.O.D.—2% C.O.D.
10% DISCOUNT ON LOTS OF 50 OR MORE.

RAVAC ELECTRONICS CORP.
432 Fourth Avenue
New York 16, N. Y.

the ratio of effective force on a blocked speaker cone to the current flow through the system creating the force.

4. The "Damping Factor" is the ratio $r/2m$ where r is resistance and m is mass. The time constant of the structure may be considered $1/(r/2m)$ and corresponds to the time for a decay to 1/2.718 of maximum.

5. "Critical damping" exists when $r = 2\sqrt{sm}$ where s represents stiffness. This means that a system returns to its static position from a displacement without any oscillatory motion. Electrical trigger circuits of the Eccles-Jordan type may be said to be critically damped.

6. "Transients" are the "on" effects of initial oscillation when a system is set into forced vibration. The steady state is reached when these oscillations are damped out. Transients also appear as "off" effects when the driving force is removed and final exponential decay occurs. It is clear that highly damped systems are important in loudspeakers. Music reproduction involves abrupt on/off effects continually, and oscillatory excursions of the cone result in serious distortion. The effect is similar to extremely reverberant conditions, or to a piano played with the loud pedal constantly depressed. The human ear is highly, but not critically, damped.

7. "Linearity" may be defined as the condition where displacement is exactly proportional to the driving force. It is also required that the system respond equally well in both directions of excursion.

8. "Amplitude" distortion occurs when the system does not follow Hooke's law (displacement is proportional to the applied force) equally well in both directions. This effect may be shown with a characteristic curve similar to the E_g-I_p curve of a vacuum tube amplifier stage.

If the curve, as shown in Fig. 4, is not linear, amplitude distortion results. In order to gain some conception of the importance of symmetrical response, consider the condition in a non-linear system where two sine waves of frequencies a and b (a greater than b) are applied. The resultant frequencies will include a, b, $a-b$, $a+b$, $2a$, $2b$, $2a-b$, $2b-a$,.....! The ear responds to this garble with accurate reproduction, and the central nervous system of the listener is confused accordingly. Realizing that this is a case far more simple than is ever encountered in practice, it is clear that proper enclosures for loudspeakers are of vital importance. If the speaker cone does not see the same impedance in both directions, serious amplitude distortion will occur.

9. In any system of damped vibration the amplitude decays exponentially after shock excitation, and the ratio between successive peaks is constant. The amplitude A of the waveform envelope may then be expressed as a time function

$$A = a_{max} \epsilon^{\frac{rt}{2m}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where a_{max} is the initial peak amplitude, m is the mass and r represents resistance. The logarithmic decrement per

cycle is the natural logarithm of the ratio a_{max}/b_{max} where b_{max} is the second positive peak, and is given by

$$k = \frac{rp}{2m} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where p is the resonant period of the system.

In idealized considerations of perfect piston action from the speaker diaphragm circumference, the resistive component of radiation impedance varies in approximate proportion to the frequency squared. In all real circumstances, sections of a diaphragm are vibrating independently and interaction occurs. In addition to its own radiation impedance, each (effective) diaphragm sees a positive or negative impedance resulting from the action of the other radiators. Thus, the total radiation impedance is the sum of these impedances as seen by each diaphragm.

Where r_r is the resistive component of its own impedance and r_{r2} the resistive component of the associated impedances, the radiated acoustic power W of a diaphragm is given by:

$$W = (r_r + r_{r2})\, V^2 \times 10^{-7} \text{ watt} \ldots\ldots (3)$$

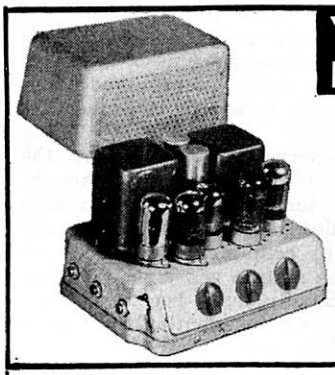
V is expressed in centimeters/seconds and represents the r.m.s. velocity of the diaphragm. Thus, in the idealized piston at frequencies where λ is greater than piston circumference, radiation of constant power requires that $V = 1/f$. This condition is approached by designing the speaker with a fundamental resonant frequency as low as possible so that the action is largely controlled by the positive reactance of mass at lower frequencies. The resistance approaches 41.3 mechanical ohms per centimeter squared at wavelengths approximating $2\pi r/2$ where r is the diaphragm radius. This produces efficient transduction of electro-acoustic energy. Where λ is greater than $2\pi r$ the effective reactance is increased to a mass approximated by an air column of cross section corresponding to the diaphragm size and a height of .8572 times the diaphragm radius.

Displacement of the diaphragm being given by V/w, it is clear that the high-level low-frequency radiation requires diaphragms large in size. This is not compatible with the spatial dispersion of high frequencies which would be ideally accomplished by a point source. Hence the aforementioned need for dual speakers in wide range systems.

Nearly all electrical phenomena that could be applied to the design of electro-acoustic transducers have been explored experimentally.

Crystal speakers have been produced commercially for high frequency use in dual systems. Low frequency response is limited by the permissible swing without fracture of the element. In generating ultrasonic frequencies in the upper region of the spectrum (50 kc. to 600 mc.) crystal speakers have an important application. Magnetostriction effects are also widely applied in the lower ranges above audibility (20 kc. to 50 kc.).

Electrostatic effects have been used where one plate of a large condenser is free to move. Even harmonics may be canceled by placing the moving element



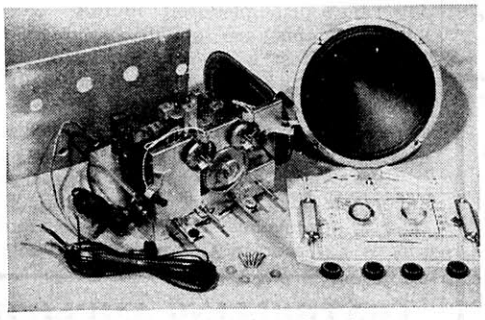
YOU'VE TRIED THE REST— NOW TRY THE BEST

10 WATT MERCURY HI FI AMPLIFIER

The H F 10 Amplifier is a general-purpose amplifier (only 6" x 8" x 6") designed for highest quality reproduction of sound, music and speech. It is engineered and manufactured to meet the highest quality standards required when used in conjunction with the new High Fidelity Pickups, FM, AM, Tuners and Mikes.

- 10 Watts undistorted 17 Watt peak.
- Inputs for new low level pick-ups, tuners and mikeh.
- Selector switch for rapid changeover to input circuits.
- Hum level—below audibility (85 db. below 10 watts).
- Separate base and treble controls.
- Treble . . . from plus 7 db. to minus 12 db. at 15000 CPS.
- Base . . . from plus 11 db. to minus 4 db. at 40 CPS.
- 4, 8, 16 and 500 ohm output.
- Hermetically sealed components used throughout.

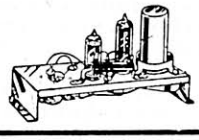
Complete with tubes and cover. **$26.46**



Famous National Brand

FM & AM RADIO CHASSIS MODEL T5

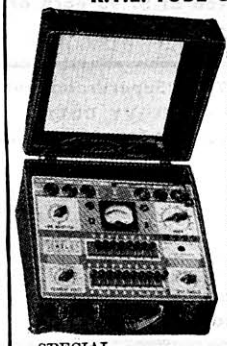
9 tubes including rectifier, Super-Het Am-FM radio receiver designed to operate on 105/125V AC, 50/60 cycles. Power consumption approximately 75 watts. Contains the following tubes: 2 6BA6, 2 6AU6, 12AT7, 6BE6, 6T8, 6K6, 5Y3GT. 10" Auditorium type Dynamic Speaker provides the tonal balance for the finest recordings and symphonic music. Advanced FM and "Tonalizer" circuit for a new standard of quality and reception. On-Off and Automatic volume control; Band selector and phono switch; Tuning control. Built-in "FM-Tenna" — specially designed FM Di-Pole antenna for excellent FM reception. Complete with tubes. **$59.95**



This fine piece of equipment is being sold at almost the price of the tubes alone. A real bargain while quantity lasts.

Each **$3.25**

R.T.L. TUBE CHECKER



MODEL 130. Slide switch operation. For all standard 4, 5, 6, 7, octal and loctal miniature series with two spare positions. Filament selective. D.C. voltmeter and battery tester range 0-10-100-1000. Portable model—leatherette covered wood case with cover. Regular Price... **$51.00**

SPECIAL— this month only..... **$39.95**

Quantity limited — order now!

CIRCULAR 35 WATT FLUORESCENT LIGHT FIXTURE

Complete with G.E. ballast starter and bulb. Ideal for kitchen, bathrooms, bedrooms and shops. Available in flush ceiling mounting or 4" cup adapter mount.

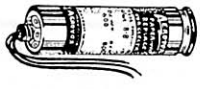
Only..... **$16.95**

METAL CAN AEROVAX REPLACEMENT FILTER CONDENSERS

Replaces 8x8 at 600 working volts. DC test volt 800.

Each . **$1.29**

10 for . **11.75**



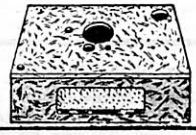
"ULTRA MIKE" WIRELESS MICROPHONE

Light — Economical operation. Completely self contained. No connections to power lines. Complete with batteries, tubes, etc. Retails at $18.00

Your price, Each **$6.63**



RECORD PLAYER CASE



Simulated Leather Cover. 11"x13"x5". All holes punched. A real buy Each **59c**

Write for our new, FREE 1948 Catalog Terms: 25% Deposit with order Balance C.O.D. F.O.B. Chicago.

Mort's Radio Shack

630 W. RANDOLPH STREET CHICAGO 6, ILL.

RADIO COURSES

- RADIO OPERATING
- CODE
- RADIO SERVICING
- F. M. TELEVISION
- REFRIGERATION SERVICING

Write for Catalog and Picture Brochure
Personal Counseling Service for Veterans

Y.M.C.A. TRADE & TECHNICAL SCHOOLS
15 W. 63rd St. (Nr. B'way) New York City

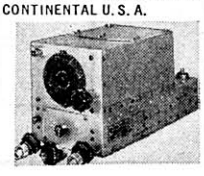
TUNING CONTROL KNOBS For Command Set Receivers

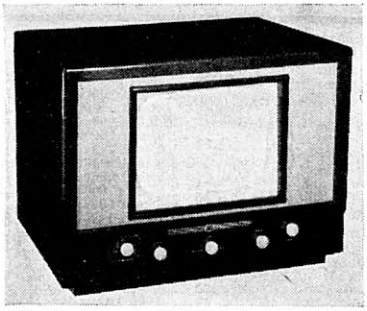
69c ea. 3 for $2. Postpaid in CONTINENTAL U. S. A.

BC 454, etc. series with locking sleeve. Brand new, not surplus. Makes tuning simple for fixed or mobile use.

Send for Latest Bulletin

ALVARADIO, Dept. 123
903 S. Alvarado, Los Angeles 6, Cal.





MASTERPIECES IN CABINETRY

Television cabinets specially engineered for 12" and 15" Standard and De Luxe "Transvision" models. Also available for 12" and 15" Standard and Champion "Television Assembly" models. Exclusively designed tables to match. Various finishes. Write for particulars.

TEL-CRAFT COMPANY
108 Havemeyer St. Brooklyn 11, N. Y.

ACORN says:

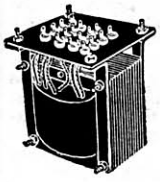
"KEEP COOL WITH OUR HOT WEATHER SPECIALS"

The "Juggernaut"
EXTRA HEAVY DUTY
PLATE TRANSFORMER



Primary 118v 25-60 cycle with two separate 118v primaries, used on either 110v or 220v. Secondary 800v center tapped @ 775 mils extraordinary regulation when loaded to 900 mils. Fully cased; 4 mtg holes. Size 6½" x 6½" x 7⅛".

Refreshingly priced at $7.95 each or a cool 3 for $21.00



The "Superdreadnaut"
HEAVY DUTY
POWER TRANSFORMER

Primary 110/220v 60 cycles
Secondary #1-410-0-410v at 400 mils
#2-6.3v at 3 amps
#3-6.9v at 13.5 amps
#4-5.0v at 3 amps
#5-2.5v at 1.75 amps
Size 6½" x 5½" x 6½". Made by General Electric for U. S. Navy.

A breeze at $7.95 each or a light blow at 3 for $21.00

The "Cruiser"
UNIVERSAL
POWER TRANSFORMER



Primary 115v 60 cycles
Secondary 720v c.t. at 150 mils
6.3v at 4 amps
5.0v at 3 amps
Half shell mtg with mtg centers 2½ by 3⅛
Size 3¾" x 3⅛"

A stimulating price at only $3.49 or 3 for $10.00

METERS

GE 2½"-0-5 ma	$3.49
GE 2½"-0-1 amp RF	3.49
GE 2½"-0-1 ma DC (0-30) Scale	3.49
GE 2½"-0-3 amps DC	3.49
Weston 2½"-150-0-150 microamps Blank Scale	3.49
Weston 3"-0-2 ma	3.95



JENSEN 10" PM SPEAKER
Alnico V Magnet

Jensen "Standard Series" P10T ST 119. An excellent speaker for good quality radio sets or PA systems. Output undistorted 8 watts. Voice coil impedance 6-8 ohms.

A great value at $4.69

Hammurland Midget Capacitors "MC"

MC 250 260 mfd. $.69 ea. 10 for $6.50
MC 325 320 mfd. .79 ea. 10 for 7.50

Electrolytic Condensers FP Type in Cans

10 @ 350v, 30 @ 300v, 20-20 @ 25v	$ .39
30 @ 450v, 20 @ 450v, 10 @ 450v, 20 @ 25v	.99
20-20 @ 450v	.74
20-20-20-20 @ 450v	1.29
20-20 @ 400v-250v	.44
10-10 @ 350v, 20 @ 25v	.59
30-30 @ 450v	.79
100 @50v	.49
1000 @ 25v	.89
10-10-10-10 @ 400v	.59

Bathtub Condensers

2.0 Mfd 600v with side terminals @ 44c, 10 for $3.90	

Oil Condensers

2 x .02 mfd 1500v	$ .69
.1 mfd 3500v	.79
.1 mfd 7500v	1.79
.25 mfd 3000v	1.19
.15 mfd 4000v	1.39
.5 mfd 5000v	1.89
1.0 mfd 2000v	1.29
1.0 mfd 1200v	.99
4.0 mfd 1000v	.89
4.0 mfd 600v	.45
3.3 mfd 600v	.79
6.0 mfd 600v	.79
8.1 mfd 1000v	1.39
10 mfd 600v	.89
15 mfd 1000v	1.89
1.0 mfd 330v AC/1000 DC	.39
1.5 mfd 330v AC/1000 DC	.39

TLA Oil Filled

4.0 mfd 600v	$1.49
2.0 mfd 1000v	1.39

TERMS: 20% cash with order. Balance C.O.D. All prices F.O.B. our warehouse N. Y. C. No orders under $2.50.

ACORN ELECTRONICS CORP.
80 Vesey St., Dept. N8, N. Y. 7, N. Y.

between two fixed perforated stators and making push-pull connections. Polarizing potentials, problems of electrical coupling to a driving source and other difficulties have hampered continued development.

Ribbon velocity speakers, where the conductor also functions as a diaphragm, have found limited application in high frequency designs. It is difficult to obtain efficient coupling to the air, and although the surface phase relationships are exceptionally even because of the equalized energy distribution, such units are not widely used.

In electroacoustic arrangements many of the principles of purely electrical systems are equally applicable. Thus the most efficient transfer of energy occurs when the impedance relationship of the speaker unit and the source of power are conjugate. Ideally, a vacuum tube should work into a speaker which represents a pure resistance. Moving coil construction most closely approaches this condition, and this is a factor in the wide acceptance of dynamic speakers. The blocked impedance appearing at the electrical terminals of moving coil designs appears as a series *R-L* circuit. At low frequencies approaching resonance in such structures, the impedance increases and a low impedance source contributes to a mismatch reduction of efficiency.

The greatest problem in converting electrical power to acoustic power is concerned with a satisfactory impedance match between the vibrating structure and the transmitting medium, which is generally air. This is the primary reason for the use of horns, and such devices may be properly considered as transformers for coupling the diaphragm to the air. Exponential designs have been most widely used because of the sharp rise in throat resistance at relatively low frequencies for a given horn length.

REFERENCE

Michel, B.M.H.; "The Design of Loudspeaker Systems," Radio-Electronic Engineering Edition of RADIO NEWS, June, 1945. Vol. 4, No. 6.

(Next Month: Design Data for Dividing Networks)

CONTROLLING AMPLIFIER FROM REMOTE TUNER

By G. R. STATHAM

A NUMBER of articles have been published covering radio tuners designed to feed into standard audio amplifiers to take advantage of the high quality reproduction which is usually a feature of such units.

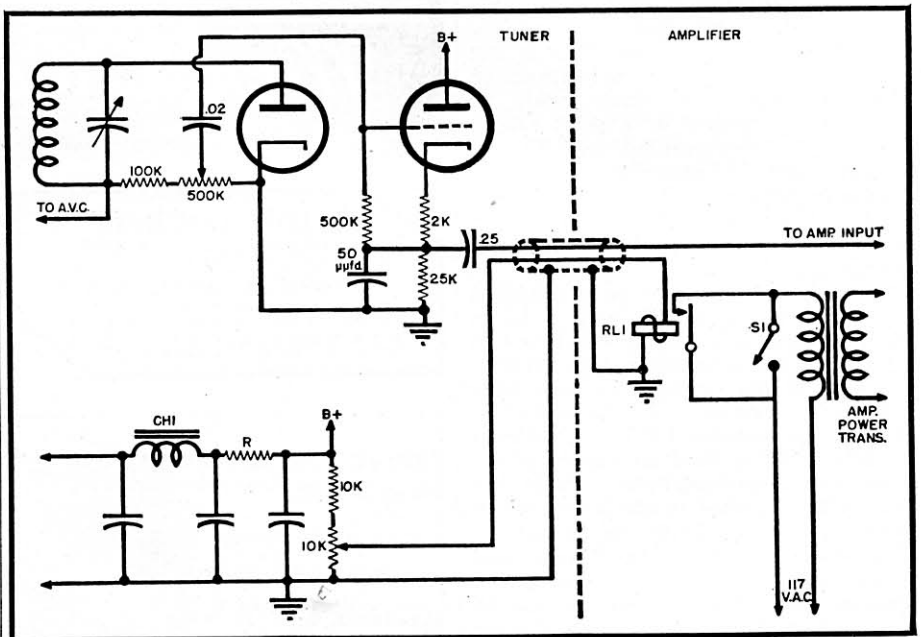
It is frequently advantageous to be able to locate such radio tuners some distance from the amplifier and this makes it desirable to incorporate in the tuner some means of fully controlling the amplifier, switching it "on" or "off" coincidentally with the tuner.

The writer was unable to locate any information on this type of control and the simple arrangement shown in the accompanying diagram was devised. Since this arrangement proved to be entirely satisfactory the idea is being passed on to other readers in the hope that it will be of some help to them.

The relay used to switch the amplifier is fed from an adjustable tap on the bleeder of the receiver power supply. The relay used was a type drawing about 6 ma. at 40 volts, but a fairly wide latitude could be allowed in choosing a relay since plenty of power is available in the tuner for its operation. The tuner actually used was a ten-tube superhet with the output stages removed.

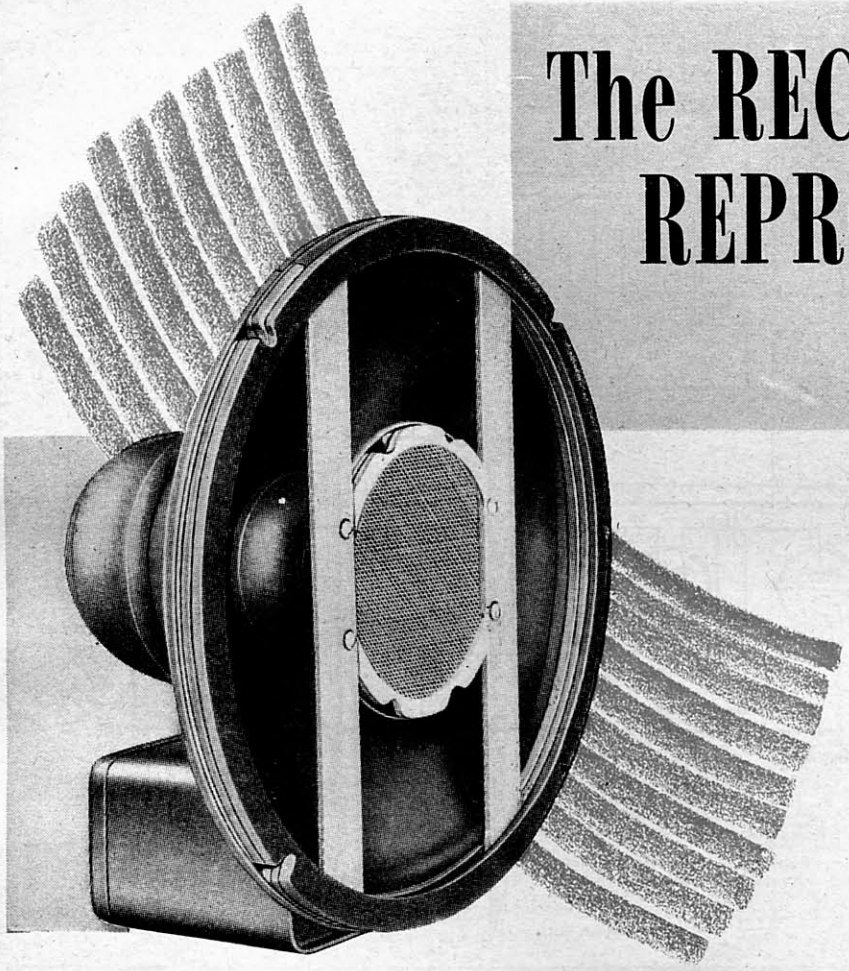
Use of a cathode follower permits almost any type of line to be used to feed audio to the amplifier without distortion or loss. The bass and treble controls in the amplifier are preset and do not usually need to be changed for the different types of programs, but tone controls could be incorporated in the tuner if desired. —30—

Diagram of remote control system. Resistor, R, is adjusted for correct value of "B+" voltage. Relay is not critical, any low current, low voltage type will do.



The RECORDING and REPRODUCTION of SOUND

By OLIVER READ
Editor, RADIO & TELEVISION NEWS



One of the new Cinaudagraph coaxial speaker units.

Part 19. Design data covering series and parallel connected filter type networks and the constant resistance networks for use with audio amplifiers.

MANY audio systems make use of separate high-frequency and low-frequency loudspeakers. In order to obtain maximum efficiency from this dual reproducing arrangement, *dividing networks* are connected between the amplifier output transformer and the voice coils of the tweeter (high-frequency speaker) and woofer (low-frequency speaker). These networks separate the frequency components in the amplifier output voltage into two bands, so that only frequencies above a certain *crossover* frequency are transmitted to the tweeter, and only those below this crossover frequency are transmitted to the woofer. Each speaker thus operates only at those frequencies at which it is most efficient and faithful.

The crossover frequency may be selected at will, but most commercially available dividing networks operate at crossover frequencies of 400 or 800 cycles. The basic facts concerning practical dividing networks may be summed up in the following brief comments:

(1) Each such network comprises a low-pass and high-pass filter with their input circuits connected either in series or in parallel. The output circuit of the high-pass filter section feeds the tweeter; that of the low-pass filter, the woofer.

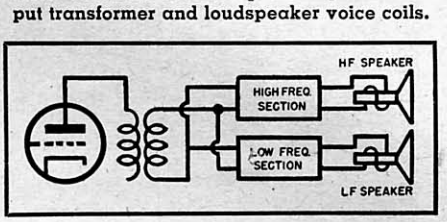
(2) At the crossover frequency, the high- and low-frequency power outputs are equal.

(3) With respect to the attenuation at the crossover frequency, the dividing network should provide 12 db. minimum attenuation one octave from the crossover frequency.

(4) The *constant-resistance* type of dividing network is a specific form which, when terminated in the proper resistance load, will offer a constant input resistance over a frequency band. The constant-resistance type network is convenient in some instances, since each of its capacitive components are identical in value, as are each of its inductive components.

Circuit diagrams of dividing networks are given in Figs. 2 and 3, together with the formulas for obtaining the values of their capacitive and inductive elements. The arrangements shown in Fig. 2 are the conventional series- and parallel-connected filter-type networks. Those given in Fig. 3 are constant-resistance networks. In the latter groups, two of the circuits (A and C) will provide only about 6 db. attenuation at 1 octave from the crossover frequency, and should be employed only in those specific cases where this low attenuation may be tolerated.

Fig. 1. Method for inserting dividing network between secondary of amplifier output transformer and loudspeaker voice coils.



Position of Network in Amplifier

The band-separating action of the dividing network might be obtained at several points in a conventional audio amplifier. In standard practice however, the dividing network is almost always connected between the secondary winding of the amplifier output transformer and the loudspeaker voice coils, as shown in Fig. 1. In this way, one output amplifier stage is made to serve both loudspeakers.

Each network section must carry the full power delivered to the loudspeaker which it supplies. Network components accordingly must be capable of handling these power levels safely. At the same time, the resistance of the inductors must be of the lowest possible value, consistent with required inductance, in order to minimize insertion losses.

The impedances out of, and into which the practical dividing network operates are identical with the rated voice coil impedance of the speakers. Thus the R_0 value that appears in the formulas.

Use of Tables

All component values for dividing networks may be calculated by means of the formulas given in Figs. 2 and 3. However, Tables 1 and 2, which list these values calculated with sufficient accuracy for critical applications, are included herein for the reader's convenience.

Tables 1 and 2 list all condenser and inductor values required, respectively, in conventional and constant-resistance type dividing networks. These tables are based upon an R_0 value of 10 ohms and an m of 0.6. All capacitance values are given in microfarads and all inductance values in millihenries, for common crossover frequencies every 50 cycles from 100 to 1000 cycles.

When working with systems in which $R_0 = 10$, all C and L values may be read in the corresponding frequency column directly from Table 1 for conventional networks, or from Table 2 for the constant-resistance type. For R_0 values other than 10, the chart values may be operated upon to yield values required for the new impedance, thus, for a value (R_X) other than R_0 (10 ohms), multiply all L values corresponding the desired crossover frequency by R_X/R_0, and divide all C values by this same factor.

As an illustration of the use of the R_X/R_0 factor, consider the following example: A conventional dividing network is required to work between 16 ohms at a crossover frequency of 450 cycles. At 16 ohms, $R_X/R_0 = 16/10 = 1.6$. All L values in the 450 cycle column of Table 1 must be multiplied by 1.6, and all C values in the same column must be divided by 1.6:

$C_1 = 70.76/1.6 = 44.22$ μfd.
$C_2 = 22.11/1.6 = 13.81$ μfd.
$C_3 = 35.38/1.6 = 22.11$ μfd.
$C_4 = 17.69/1.6 = 11.05$ μfd.
$C_5 = 56.61/1.6 = 35.38$ μfd.
$L_1 = (5.66)\ 1.6 = 9.056$ mh.
$L_2 = (3.54)\ 1.6 = 5.664$ mh.
$L_3 = (1.77)\ 1.6 = 2.832$ mh.
$L_4 = (7.08)\ 1.6 = 11.328$ mh.
$L_5 = (2.21)\ 1.6 = 3.536$ mh.

To find the capacitance and inductance values required at 10 ohms for some crossover frequency (f) in cycles-per-second, other than one of the 19 frequencies given in the two charts, first locate the C and L values in the "100 cycle" column, then multiply each of these values by $100/f$. If a different impedance (R_X) as well as a different frequency (f) is required, locate both the capacitance and inductance values in the "100 cycle" column of the chart, and multiply the capacitances thus obtained by $1000/(fR_X)$, and the inductance by $(10R_X)/f$.

As an illustration of the use of these last two formulas, consider the following example: A constant-resistance dividing network is required with a crossover frequency of 500 cycles, to work between 16 ohms. The 100 cycle values (Table 2) will be multiplied thus:

$C_1 = 159.15 \times 0.125 = 19.89$ μfd.
$C_2 = 225.04 \times 0.125 = 28.13$ μfd.
$C_3 = 112.52 \times 0.125 = 14.06$ μfd.
$L_1 = 15.91 \times 0.32 = 5.09$ mh.
$L_2 = 11.25 \times 0.32 = 3.60$ mh.
$L_3 = 22.50 \times 0.32 = 7.20$ mh.
$1000/(fR_X) = 1000/(500 \times 15) = 0.125$
$(10R_x)/f = (10 \times 16)/500 = 0.32$

As with any combination of speakers, attention must be paid to the proper phasing of coaxial units. Both cones must move in the same direction at the same moment to be properly in phase. Correct polarity may be observed by connecting a battery to the two voice coils momentarily. Both cones should definitely move in the same direction for the same battery polarity.

Correct impedance matching must also be observed for maximum efficiency of dual or coaxial speaker combinations. Specific examples of this impedance matching will be discussed in some detail later in this series.

REFERENCE

Aerovox Research Worker, Vol. 17, No. 10.

(To be continued)

f_c =	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
C_1	318.5	212.30	159.24	127.38	106.16	90.98	79.62	70.76	63.70	57.90	53.08	48.98	45.48	42.46	39.80	37.50	35.38	33.52	31.85
C_2	99.47	66.34	49.76	39.81	33.17	28.43	24.88	22.11	19.91	18.09	16.59	15.31	14.21	13.27	12.44	11.72	11.06	10.47	9.95
C_3	59.15	106.15	79.62	63.69	53.08	45.49	39.81	35.38	31.85	28.95	26.54	24.49	22.74	21.23	19.90	18.75	17.69	16.76	15.91
C_4	79.57	53.07	39.81	31.84	26.54	22.74	19.90	17.69	15.92	14.47	13.27	12.24	11.37	10.61	9.95	9.37	8.84	8.38	7.96
C_5	254.64	169.84	127.39	101.90	84.93	72.78	63.69	56.61	50.96	46.32	42.46	39.18	36.38	33.97	31.84	30.00	28.30	26.82	25.46
L_1	25.46	16.98	12.74	10.19	8.49	7.28	6.37	5.66	5.10	4.63	4.25	3.92	3.64	3.40	3.18	3.00	2.83	2.68	2.55
L_2	15.91	10.61	7.96	6.37	5.31	4.55	3.98	3.54	3.18	2.89	2.65	2.45	2.27	2.12	1.99	1.87	1.77	1.68	1.59
L_3	7.96	5.31	3.98	3.18	2.65	2.27	1.99	1.77	1.59	1.45	1.33	1.22	1.14	1.06	0.995	0.937	0.884	0.838	0.796
L_4	31.85	21.23	15.92	12.74	10.62	9.09	7.96	7.08	6.37	5.79	5.31	4.90	4.55	4.25	3.98	3.75	3.54	3.35	3.18
L_5	9.95	6.63	4.98	3.98	3.32	2.84	2.49	2.21	1.99	1.81	1.66	1.53	1.42	1.33	1.24	1.17	1.11	1.05	0.995
	C in μfds.				L in mh.			m = 0.6			R_0 = 10 ohms				f in cycles				

Table 1. Conventional dividing networks. See Fig. 2 for circuits.

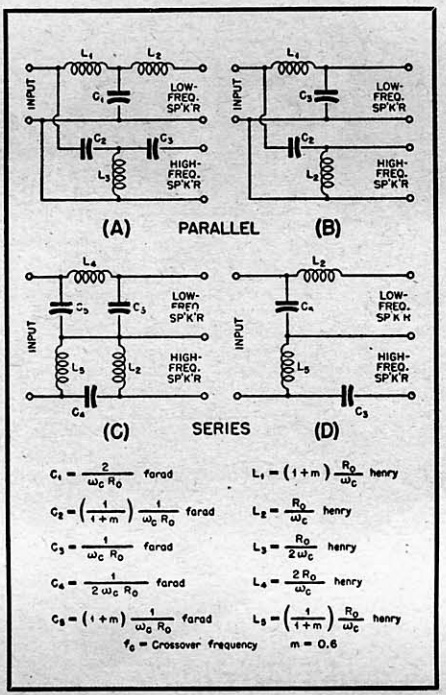


Fig. 2. Conventional series and parallel connected filter type networks along with the formulas for obtaining LC component values.

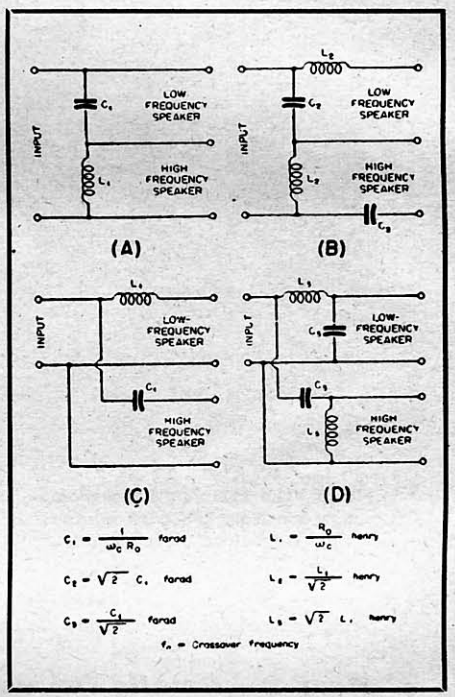


Fig. 3. Four types of constant-resistance networks and associated formulas for computing values. See note in text on A and B.

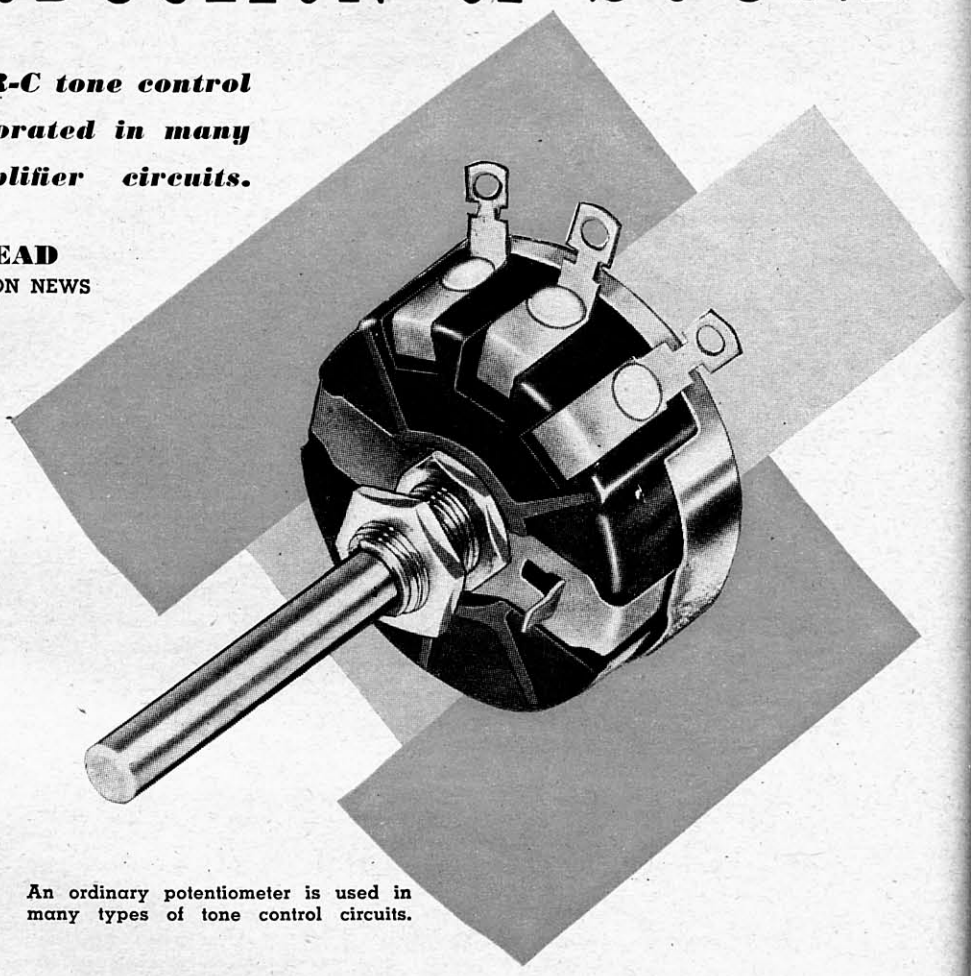
f_c =	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
C_1	159.15	106.15	79.62	63.69	53.08	45.49	39.81	35.38	31.85	28.95	26.54	24.49	22.74	21.23	19.90	18.75	17.69	16.76	15.91
C_2	225.04	150.10	112.58	90.06	75.05	64.32	56.29	50.03	45.03	40.93	37.53	34.63	32.15	30.02	28.14	26.51	25.01	23.69	22.50
C_3	112.52	75.05	56.29	45.03	37.52	32.16	28.14	25.01	22.51	20.46	18.76	17.31	16.07	15.01	14.07	13.25	12.50	11.84	11.25
L_1	15.91	10.61	7.96	6.37	5.31	4.55	3.98	3.54	3.18	2.89	2.65	2.45	2.27	2.12	1.99	1.87	1.77	1.68	1.59
L_2	11.25	7.50	5.63	4.50	3.75	3.22	2.81	2.50	2.25	2.04	1.87	1.73	1.60	1.50	1.41	1.32	1.25	1.19	1.12
L_3	22.50	15.00	11.26	9.00	7.50	6.44	5.62	5.00	4.50	4.08	3.74	3.46	3.20	3.00	2.82	2.64	2.50	2.38	2.24
	C in μfds.				L in mh.						R_0 = 10 ohms				f in cycles				

Table 2. Constant-resistance dividing networks. See Fig. 3.

The RECORDING and REPRODUCTION of SOUND

Part 20. A discussion of R-C tone control systems which are incorporated in many conventional audio amplifier circuits.

By OLIVER READ
Editor, RADIO & TELEVISION NEWS



An ordinary potentiometer is used in many types of tone control circuits.

NEARLY all of the simpler means for tone control or shaping the response curve are based on simple high and low pass filter circuits. For example, the circuit of Fig. 2A is a simple high pass filter while that of Fig. 2B is a low pass system.

In operation, the output from the circuit of Fig. 2A will increase with increasing frequencies applied to the input, while that from Fig. 2B will decrease as the frequency is increased. This is caused by the fact that the reactance of *C* decreases with increasing frequency and therefore, a smaller portion of the applied voltage appears across the condenser as the frequency increases. Theoretically the above action is true from zero frequency (d.c.) to infinitely high frequency, but for all practical purposes the effect is restricted to a small section of the spectrum. The change in response is negligible beyond the frequency limits at which the condenser reactance is equal to 1/10 and 10 times the value of resistance in the circuit. There are many variations of these two simple circuits which are used for treble or bass attenuation.

Typical Tone Compensation Systems

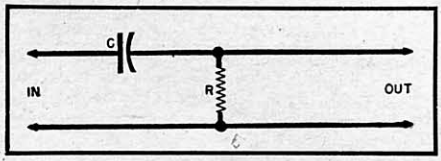
To evaluate any form of tone control used in connection with an amplifier it is necessary to establish a reference point for both gain and frequency. For this discussion we will consider the gain of the amplifier at 400 cycles-per-second as the reference point, and all circuits mentioned will be classified accordingly as low or high frequency boost or attenuation systems.

The circuit of Fig. 1 is perhaps the most commonly used form of tone control but is seldom recognized as such. It consists of nothing more than a coupling condenser and the following grid resistor. By proper selection of the values of *C* and *R* this circuit may be adjusted to give negligible attenuation at the reference frequency and increasing attenuation as the frequency is reduced.

Due to other design considerations in the amplifier, this form of tone control is made variable only on rare occasions.

The opposite of the action secured from the circuit of Fig. 1 may be obtained by the use of either Fig. 3A or 3B. Both of the circuits in Fig. 3 operate on the principle that the total impedance in the circuit increases as the frequency is reduced, thus forming a load impedance which varies inversely with the frequency. The circuit of Fig. 3A is most commonly used as the plate load for voltage amplifier tubes whose operating conditions are so adjusted that the stage gain increases as the plate load impedance rises. The circuit of Fig. 3B is commonly used with a tapped volume control and may be inserted as a second detector load impedance or as the grid return circuit of an amplifier stage. When the circuit of Fig. 3A is used as a microphone or pickup load impedance the dotted line shown is used as the high output lead. When connected in this manner the condenser shunts the output terminals and therefore increases the ratio of output to input impedance as the frequency decreases. This circuit could be considered high frequency attenuation just as well as low frequency boost since the operation is the same.

Fig. 1. Commonly used form of tone control.



Both circuits of Fig. 3 may be made variable in response by using different values of *C* selected by a switch or other means.

Fig. 4A and 4B show the most commonly used means of providing tone control on the upper portion of the audio spectrum. The most frequently used position for these circuits in an amplifier is the grid circuit of one or more of the amplifier tubes.

The circuit of Fig. 4A is used quite frequently by radio receiver manufacturers to give a smooth tone control

which operates on the high frequency end of the audio passband.

Condenser C is usually selected so that when R_2 is zero the high frequency attenuation starts at a frequency near the reference point. As R_2 is increased C becomes increasingly less effective in bypassing the high frequencies, thus providing smooth control of the high frequency response of the amplifier. In the circuit of Fig. 4B both R_1 and R_2 are usually relatively high values of resistance and C a small capacitance. In this circuit the output at and below the reference frequency is approximately equal to $E_{in}R_2/(R_1+R_2)$ and increases to a value approaching E_{in} as the frequency increases. When properly designed, all the foregoing circuits attenuate certain frequencies while maintaining normal response from the reference frequency to the opposite end of the band.

Fig. 5A and 5B show circuits similar to the above but applied in a manner which gives a stage gain variation with frequency. This is accomplished by connecting the filter section into a feedback circuit. Fig. 5A will boost the higher frequencies when condenser C is chosen to have a value insufficient to provide an adequate bypass for cathode resistor R at the reference and lower frequencies. At the higher frequencies C becomes an effective bypass and thus removes degeneration from the tube circuit.

When properly chosen values of R_1, R_2, and C are used in the circuit of Fig. 5B, the stage may be made to have considerable inverse feedback at the high frequencies and relatively little at the reference and low frequencies. Condenser C should be so chosen that its reactance at the low frequencies is high with respect to the total impedance in the series-parallel combination of R_1, R_2, and R. Resistor R_1 is used to limit the amount of feedback at the high frequencies and R represents the impedance in the driving source or, in practice, the output impedance of the preceding stage (i.e., R_b and R_p of the preceding stage in parallel). The circuit of Fig. 5B must be carefully designed since the R-C network may give sufficient phase-shift to the feedback signal for the stage to become regenerative at an unwanted frequency.

A word about the position of tone control systems in an amplifier may be in order at this time. Since nearly all of the simple tone control circuits described may be classified as the opposite of the name applied, care must be taken that a low frequency boost circuit is not followed by a high frequency boost circuit which operates by reducing the reference and low frequencies. For example, the circuit of Fig. 3A or 3B should not be followed by the circuit of Fig. 2A since these two circuits will tend to cancel out and produce flat response. In most phono and microphone amplifiers some bass boosting and for high fidelity some

(*Continued on page* 89)

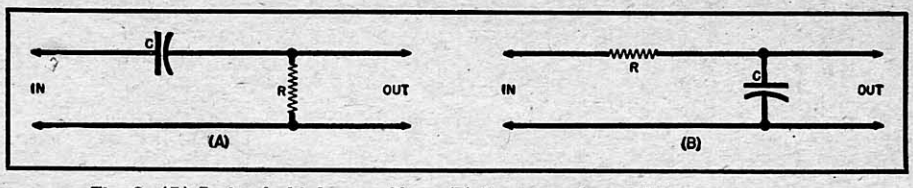


Fig. 2. (A) A simple high pass filter. (B) A commonly used low pass system.

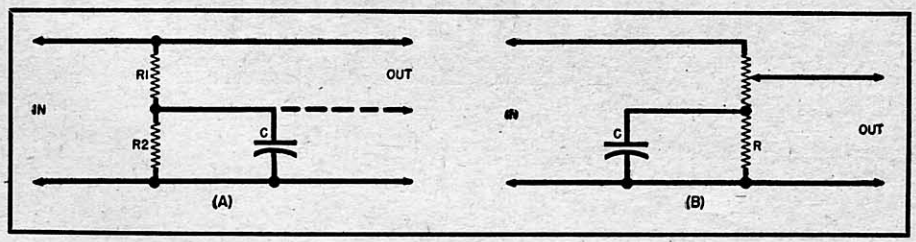


Fig. 3. (A) Circuit commonly used as the plate load for voltage amplifier tubes. (B) Circuit often used with a tapped volume control. This circuit may be inserted as a second detector load impedance in amplifier.

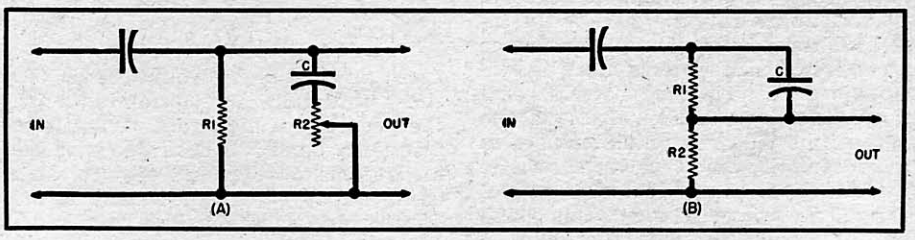


Fig. 4. (A) Circuit used in radio receivers to give smooth tone control on the high frequency end of the audio passband. (B) Another frequently used circuit which provides tone compensation for commercially-built receivers.

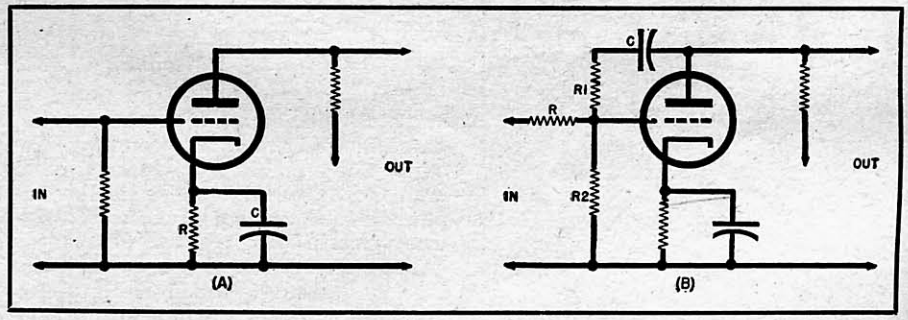
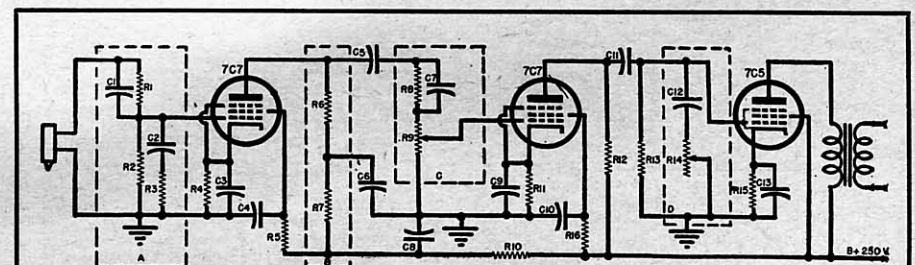


Fig. 5. (A) This circuit will boost the higher frequencies when condenser, C is of too low a value to provide an adequate bypass for the cathode resistor at the reference and lower frequencies. (B) By choosing component values, this circuit can provide inverse feedback on the highs.

Fig. 6. A pentode input amplifier which provides bass boost action. See Table 1.



R_1—1.5 megohm, ½ w. res.
R_2—3.3 megohm, ½ w. res.
R_3, R_6—100,000 ohm, ½ w. res.
R_4—1000 ohm, 1 w. res.
R_5—1.2 megohm, ½ w. res.
R_7—150,000 ohm, ½ w. res.
R_8, R_{13}—250,000 ohm, ½ w. res.
R_9—250,000 ohm, var. res.
R_{10}—47,000 ohm, ½ w. res.
R_{11}—470 ohm, 2 w. wirewound res.
R_{12}—68,000 ohm, ½ w. res.
R_{14}—1 megohm var. res.
R_{15}—360 ohm, 2 w. wirewound res.
R_{16}—330,000 ohm, ½ w. res.
C_1—100 μμfd. mica cond.
C_2, C_7—.001 μfd., 400 v. cond.
C_3—25 μfd., 25 v. elec. cond.
C_4—.1 μfd., 400 v. cond.
C_5, C_{11}—.05 μfd., 400 v. cond.
C_6—.01 μfd., 400 v. cond.
C_8—8 μfd., 350 v. elec. cond.
C_9, C_{13}—50 μfd., 25 v. elec. cond.
C_{10}—.25 μfd., 400 v. cond.
C_{12}—.005 μfd., 400 v. cond.

treble boost is desirable. Bass boost may be obtained by using the circuit of Fig. 3A in the input grid circuit (with the dotted line connected to the input grid) or the same circuit in the plate load for a pentode input amplifier as shown in Fig. 6. Treble boost may be obtained by using the circuit of Fig. 4B in the following grid circuit or the circuit of Fig. 5A in the cathode circuit of the following tube. If treble attenuation is desired, the circuit of Fig. 4A may be used in the grid circuit of the output tube. With push-pull output stages the condenser C and resistor R_2 of Fig. 4A may be connected from grid to grid. These circuits are also shown in the schematic diagram Fig. 6.

In designing an amplifier having any of the bass or treble boost circuits described it must be remembered that the over-all gain of the amplifier is reduced at the reference frequency. Therefore, sufficient additional gain at the reference frequency must be included in the design to make up for that lost in the tone control circuits. The design of the amplifier must also provide for the additional gain which occurs at the boosted frequencies so that overloading, with resulting distortion at these frequencies, does not occur.

In the circuit of Fig. 6, a slight modification has been added in section A which was not covered in the description of Fig. 3A. In Fig. 3A the low frequency boost is obtained at the cost of high frequency attenuation which becomes quite extensive as the frequency approaches the high end of the audio band. The addition of the 100 $\mu\mu$fd. condenser and the 100,000 ohm resistor in the circuit limits the high frequency attenuation of this circuit to approximately the attenuation at the reference frequency. The resistor and condenser values used in this circuit are found by calculation of admittances and impedances at each of several frequencies in the band desired, including the reference frequency.

These calculations, using the values assigned, indicate that the signal applied to the grid of the input tube, assuming constant voltage from the pickup, will be approximately 61% at 50 c.p.s., 33% at 100 c.p.s., 21.5% at 400 c.p.s., and 21.8% at 4000 c.p.s.

Table 1. Attenuation of Section D in Fig. 6

Frequency (in c.p.s)	Over-all Gain	Attenuation of Sec. D. Max.	Min
50	.61 x 164 x .5 x 80 x 1		4000
100	.33 x 159 x .503 x 80 x 1	2115	2115
400	.215 x 145 x .542 x 80 x 1		1352
400	.215 x 145 x .542 x 80 x .95	1287	
4000	.218 x 120 x .865 x 80 x 1		1810
4000	.218 x 120 x .865 x 80 x .35	633	

Sections B and C in Fig. 6 both affect the impedance of the plate load and therefore the gain of the input Type 7C7 tube. The gain at each of several frequencies in the desired band was obtained by calculating the plate load impedance at each frequency and interpolating the gain from the R-C data given in the new *Sylvania* Technical Manual. At frequencies of 50, 100, 400, and 4000 cycles-per-second the gain of the input stage (assuming constant grid signal) will be approximately 164, 159, 145, and 120 respectively.

Section D has been used in the circuit of Fig. 6 to illustrate the most common form of high frequency attenuation circuit. The condenser value has been chosen to give a negligible effect at the reference frequency when the resistance, R_{14}, is set at zero. The plate resistor, R_{12}, for the second amplifier has been assigned a relatively low value so that the tube operation approximates a constant current generator. Under these conditions the voltage across the total plate impedance consisting of C_{12}, R_{12}, R_{13}, and the tube R_p in parallel is equal to IZ with Z variable with frequency. Using the values assigned, the signal reaching the output tube grid will approximate 100%, 100%, 95%, 88%, and 35% of the low frequency value at the frequencies of 50, 100, 400, 800, and 4000 cycles-per-second when the 1 megohm control is set for maximum high frequency attenuation. When the 1 megohm tone control resistance is all in the circuit no appreciable high frequency attenuation will be introduced and the response will be that caused by sections A, B, and C.

By summarizing the results described above it is possible to plot the approximate response curve of the circuit in Fig. 6 from the pickup to the grid of the output tube from calculations of the over-all gain at the several frequencies. See table above.

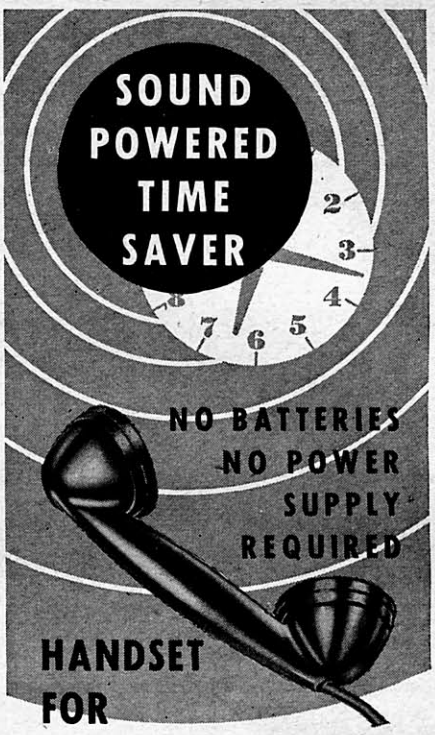
With 400 c.p.s. as the reference the response with minimum attenuation in section D would be + 9.4 db., + 3.9 db., 0, and + 2.54 db. at frequencies of 50, 100, 400, and 4000 cycles per second. With section D set for maximum high frequency attenuation the response at the same frequencies would be + 9.83 db., + 4.32 db., 0, and −6.127 db. respectively.

In all of the above calculations and results reported, all effects of tube and stray capacities have been neglected and it has been assumed that the output from the pickup is constant over the frequency range. Since these conditions do not exist in actual practice the circuit shown in Fig. 6 should be accepted as a basic illustration of the circuits used for tone compensation and control systems, and may require some modification if these exact characteristics are desired in a practical design.

REFERENCE

Sylvania News, Vol. 15, No. 1.

(*To be continued*)



- TV & FM INSTALLERS
- TELEPHONE,
- TELEGRAPH and
- POWER LINEMEN

and wherever
EMERGENCY SERVICE
is required

The Wheeler Sound-Powered handset — complete within the single instrument — is a new development of an old principle. It's a step and time saver on any job where temporary, convenient and inexpensive telephone service is needed. No power source, no batteries to bother with. Operates over two conductor full metallic or single wire, ground return circuit. Safe, tough, quick, dependable. Efficient talking up to 25 miles. See your local jobber or write, wire or phone Waterbury for complete details.

MAGNET WIRE • COILS • BALLASTS

THE
WHEELER
INSULATED WIRE CO., INC.
2610 EAST AURORA STREET
WATERBURY 91, CONNECTICUT

SERVICE QUALITY WHEELER DEPENDABILITY

DIVISION OF THE SPERRY CORPORATION

The RECORDING and REPRODUCTION of SOUND

By

OLIVER READ

Editor, RADIO & TELEVISION NEWS



United Transformer Corporation's Type EG-1 interstage equalizer.

Part 21. Continuing the discussion of various means of audio frequency correction for specific applications.

IN OUR article last month we discussed many types of tone controls (equalizers) employing resistance and capacitance. Greater flexibility is had with the "resonant" type of equalizer, as it has been found from actual listener tests (see Fig. 1) that to obtain a balance between the low and high frequency response is highly desirable. For best performance, the product of the low frequency and high frequency limits of the equipment should equal approximately 500,000.

It has been established that where an audio system in a receiver was good to only 200 cycles at the low frequency and a tone control was necessary and when it limited the high frequency end to 2500 cycles the best balance of response was obtained. In the reproduction of phonograph records a similar condition exists, especially those records having a sharp drop-off at the low end. Accordingly, to obtain balance the high end frequencies are often removed unnecessarily. While the sound becomes balanced to the ear the fidelity is, unfortunately, greatly decreased. Low notes which were not reproduced originally are still not reproduced, and the high notes are missed as well. The obvious answer then is to bring back the low notes through the use of an equalizer, thus increasing the over-all fidelity rather than reducing it.

Virtually all recording systems, whether discs, sound on film, sound on wire, embossed film, etc., require playback equalization as well as equalization when the recording is being made. The necessity for equalization is apparent.

Most microphones, pickups and loudspeakers can be effectively equalized. Low frequency droop used for dialogue equalization will greatly improve the intelligibility of speech. It will also permit higher power levels from speakers used in p.a. equipment. A portion of the power normally going to the speakers and not required for intelligibility is removed.

Mid-frequency equalization (low end and high end droop) is frequently used by radio amateurs to effect a maximum signal level in the frequencies most necessary for intelligibility. Various acoustic conditions will frequently lend themselves to equalization. For example, the absorption of high frequencies may easily be 15 db. depending upon the drapes in the room, the number of people, as well as the presence of any other sound absorbing material. Another point of equalizer use comes from the realization that at low sound levels the ear is less responsive to low frequencies. This type of equalization is commonly called "bass boost."

In order to obtain smooth and positive control and not introduce hum into the audio circuits it is advisable to employ commercially made equalizers such as the CGE-1 developed by *U.T.C.* engineers. Reference to the curves will show how well such units are suited to many applications. The electrical components are stable, free from hum pickup, and dependable in operation.

This type of equalizer is readily adapted for use with commonly used audio amplifier equipment. As mentioned, the frequency correction curve with the *RC* type of tone control is a gradual slope and does not accomplish what is required in the boost condition. For example, if the circuit to be equalized is down 15 db. at 5000 cycles, an equalizer which brings back this 15 db. but also boosts 6 db. at 1000 cycles is not desirable. Accordingly, the CGE-1 unit employs resonant circuits for both the low and high frequency boost. As will be noted from the curves with 15 db. boost at 8000 cycles the response curve is flat at 2000 cycles. A similar condition exists at the low end. Two controls are required, one either boosts (accentuates) or drops (attenuates) the low frequencies and the other either boosts or drops the high frequencies. This type of equalizer is of high impedance and is designed for insertion into an audio amplifier between a triode plate and subsequent grid, or from a high impedance source (5000 to 30,000 ohms) other than a crystal microphone, to a subsequent grid loaded with 10,000 ohms.

Some insertion loss is effected by this equalizer, particularly at the maximum setting. If the amplifier system does not have excessive gain an additional audio stage may be required. As the filament and plate drain of the added tube is small, it

(*Continued on page* 157)

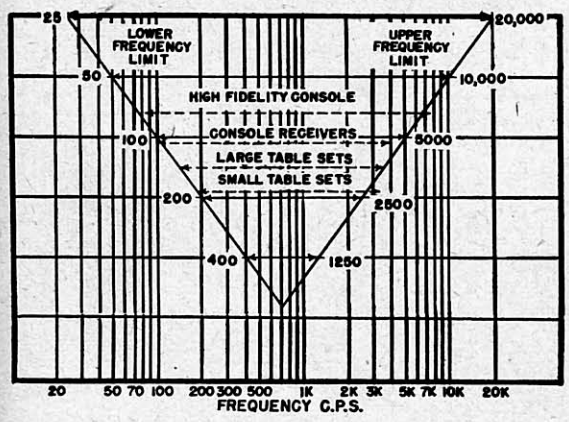


Fig. 1.

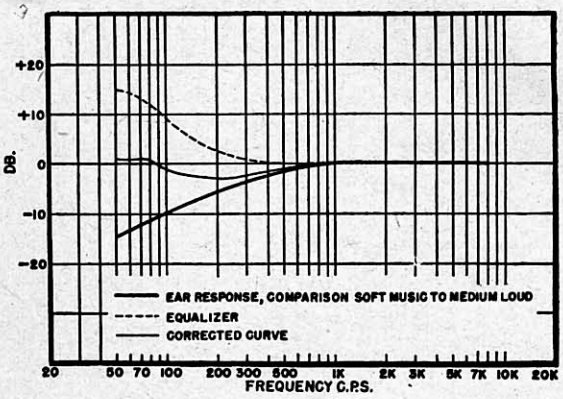


Fig. 2.

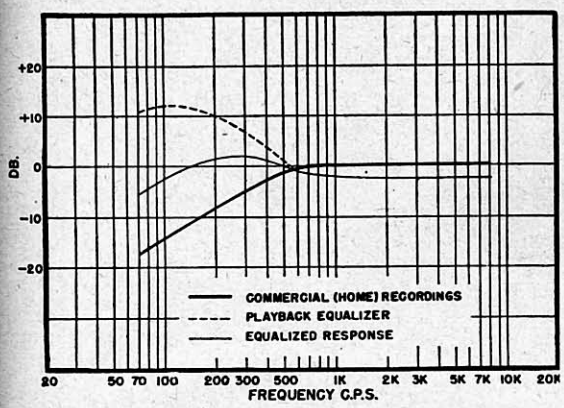


Fig. 3.

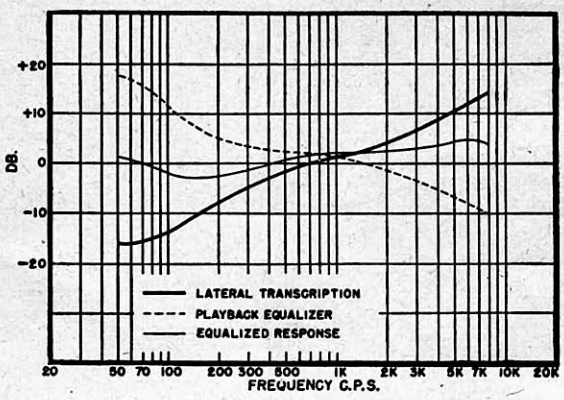


Fig. 4.

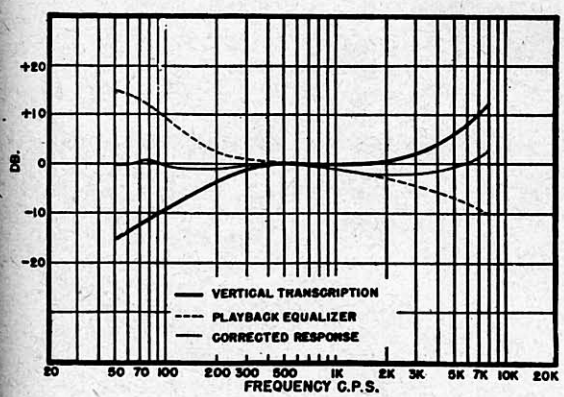


Fig. 5.

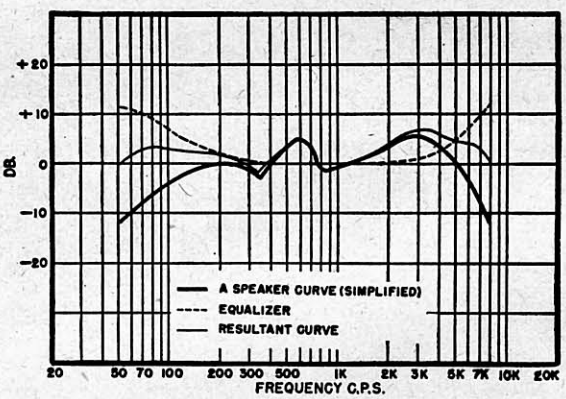


Fig. 6.

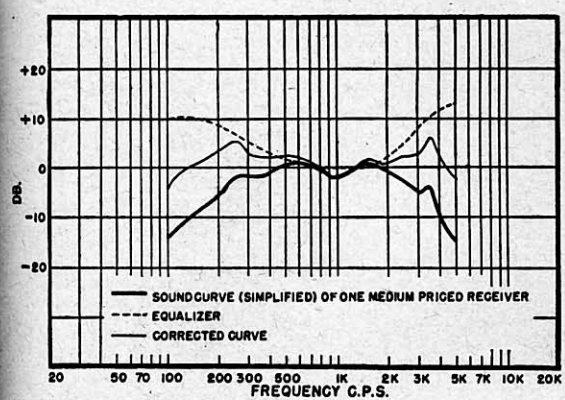


Fig. 7.

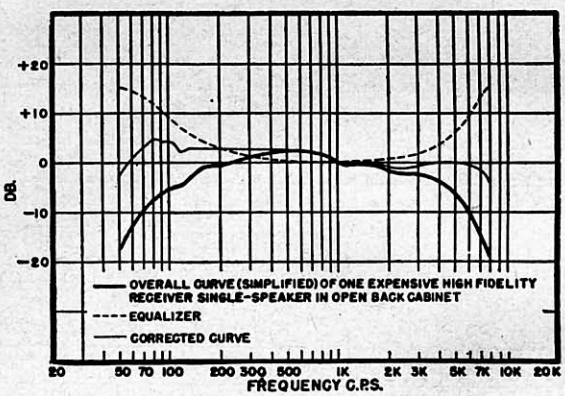


Fig. 8.

can normally be taken from the power supply of the original equipment.

Figs. 2 thru 13 illustrate the various typical curves obtained with this equalizer with the setting at maximum value.

To permit equalization for a wide variety of applications, the high frequency and low frequency boost sections are arranged for two frequencies each. In most applications the frequency desired is predetermined, and when the unit is wired into the equipment, the appropriate connections are employed. If a wide range of use is anticipated, the 50 cycle and 100 cycle

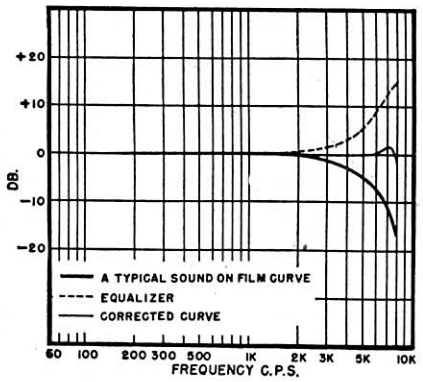


Fig. 9

terminals can be brought out to a single-pole, double-throw switch, and in like maner, the 5 kc. terminals to a similar switch, thus permitting instantaneous changeover to the desired resonant frequency.

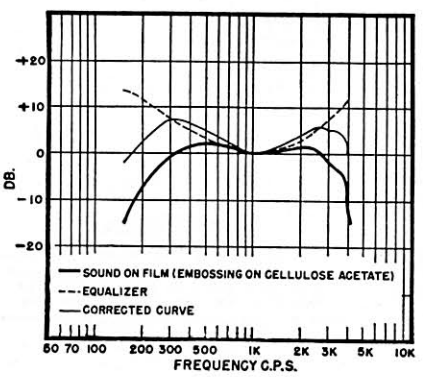
The following considerations should be observed in order to take full advantage of the possibilities of the equalizer:

1. The unit is designed to work between two impedances of 10,000 ohms, and this value of termination must be used to maintain accuracy of calibration.

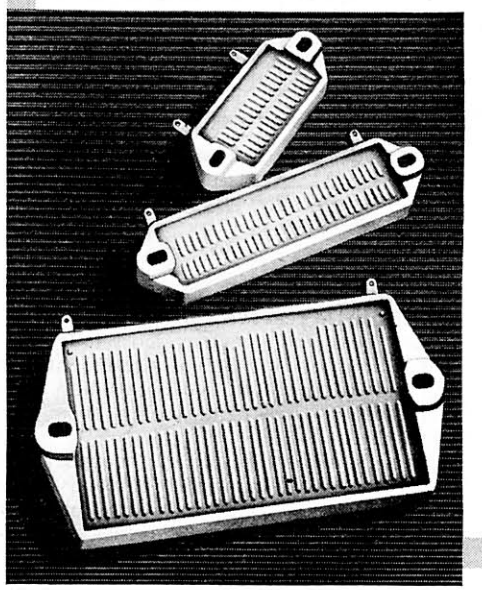
2. No distortion is introduced if the maximum level at the equalizer input is held below 2 volts, with negligible distortion at several times this value. The unit should not be used at signal levels above 10 volts.

3. When adding this type of reso-

Fig. 10



Only **WARD LEONARD** *gives you*

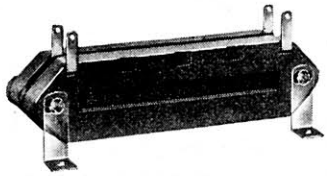


Vitrohm Plaque Resistors

For High Frequency Circuits

FOR RHOMBIC ANTENAS

For use as a terminating resistor, the 125 watt size is available in 800 ohm, 1600 ohm, and 2400 ohm, for individual use on low power rigs, and parallel or series-parallel networks on high power transmitters.



GANG MOUNTING

Two or more Vitrohm Plaque Resistors may easily be ganged to obtain other desired wattages and resistances. Illustration above shows method of mounting two units together.



SEND FOR HELPFUL CATALOG

Catalog D-130 *gives complete data and listings on stock units available in Resistors, Rheostats, and Radio Amateur Relays.* Send for your copy today!

These non-inductive Plaque resistors are especially suitable where a combination of power and high frequencies exist. Deep insulating barriers separate non-inductive winding. Special Ward Leonard vitreous enamel—tough, crazeless, acid and moisture resisting—is fused over the base, wire and terminals. Available from stock in 20, 40 and 125 watt sizes, in a wide range of resistance values.

AUTHORIZED DISTRIBUTORS EVERYWHERE

WARD LEONARD ELECTRIC COMPANY
Radio & Electronic Distributor Division
53-N West Jackson Blvd., Chicago 4, U.S.A.

Basic 3R's in Current Control

WARD LEONARD

RELAYS • RESISTORS
RHEOSTATS

RESULT-ENGINEERED CONTROL DEVICES

The Bottom of the Surplus Barrel!
FROM ALASKA AND HAWAII

DYNAMOTORS (*New*)

Type PE73 (for BC 375E) (28 V. D.C. to 1000 V. D.C.).....**$5.00** EA.

Type PE94B (for BC 522) (28 V. D.C. to 14.5—150 V.—300 V. D.C.).....**$5.00** EA.

Type DM33A (for 274-N Modulator or ARC/3 with Adaptions) (28 V. D.C. to 550 V. D.C.).....**$1.50** EA.

LP21A RADIO

Compass Loop (for 433 G, or ARN/7). New. Good. Not kept in dry storage .....**$4.50** EA.

TU5B (new) TU26B (new). Tuning Unit (375E) .....**$2.50** EA.

R.F. Section (191) for BC 348Q .....**$2.00** EA.

R.F. Section (MN26) Radio Compass .....**$3.00** EA.

Plugs for 274-N Gear PL151, PL152, PL153, PL154, PL156, PL55, PL68. Your choice any three at.....3 for **$1.00**

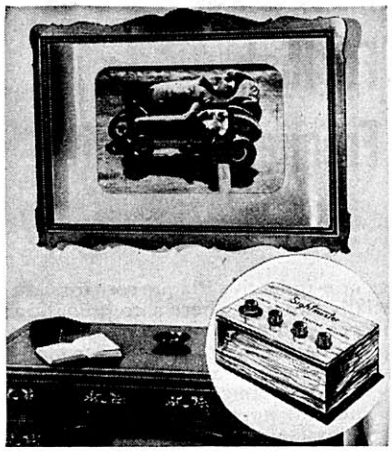
A few Command Receivers 454B, 455B. Used at **$8.95** EA. **Also** Xmtrs Type 457, 459. Used. Good. At.....**$6.95** EA.

FARWEST TRADING COMPANY, Inc.
209 FIRST AVE. SOUTH SEATTLE 4, WASH.

Radiomen, Dealers, and Distributors: PROMOTE YOUR TELEVISION BUSINESS
with the
GREAT SALES FEATURES OF

Sightmaster

TELEVISION
with the unique
"SightMIRROR"*
and REMOTE CONTROL UNIT



The OUTSTANDING DEVELOPMENT in TELEVISION for 1949!

Once again, Sightmaster leads the field with exciting new ideas in Television Set Design. *Only Sightmaster embodies the sensational "SightMIRROR" principle with Remote Control.* The first new look in television, it offers:

- *A beautiful mirror* when the set is not in operation.
- *A distinctive television screen* when the set is on, giving a clear eye-pleasing picture.
- Has *unlimited decorative applications* in cabinets, on walls, etc.

A COMPLETE LINE of TV-with-FM RECEIVERS in All Price Ranges

The Sightmaster line includes 14 distinctive models:

- Each designed for a *particular* price class.
- Each embodies the *most recent engineering improvements* in performance.
- Each built in our new enlarged plant—built for *service* and backed by a *warranty.*
- Each priced for rapid turnover and substantial profits to dealers.

Some EXCLUSIVE FRANCHISES in several television areas are still available.

RADIOMEN, DEALERS, and *DISTRIBUTORS* are invited to contact us NOW for price and discount schedules, and franchise arrangements.

*Pat. Pend.

THE SIGHTMASTER CORP.
Mfrs. of Television Receivers Exclusively
385 NORTH AVE., NEW ROCHELLE, N. Y.
N. Y. Sales Office: 220 Fifth Ave.

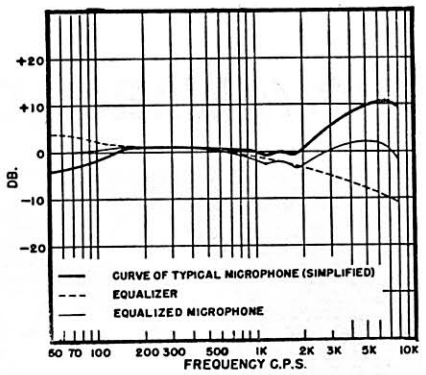


Fig 11.

nant equalizer to an amplifier with very little reserve voltage gain, a preamplifier such as cascaded triodes will result in an output voltage essentially equal to the input voltage when both maximum bass and treble boost are used.

4. When an amplifier incorporating the CGE-1 is run with no boost, the mid-frequency gain is 30 decibels over that with full boost. For best signal-to-noise ratio under these conditions,

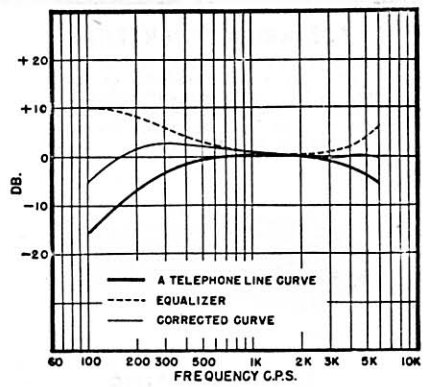


Fig. 12.

a master gain control should be used in the circuit after the equalizer itself.

Another popular commercial tone control system developed by *Thordarson* engineers is employed in the record-reproduce amplifier (Part 11, of

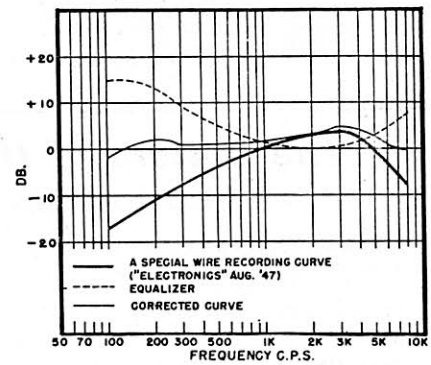


Fig. 13.

this series). It is based on the degeneration in the cathode circuit of a suitable triode amplifier.

REFERENCE:

United Transformer Corp., Bulletin CGE.

(To be continued)

GREYLOCK
A Dependable Name In
RADIO TUBES
GT, Glass and Miniature Types
All Tubes in Individual Cartons

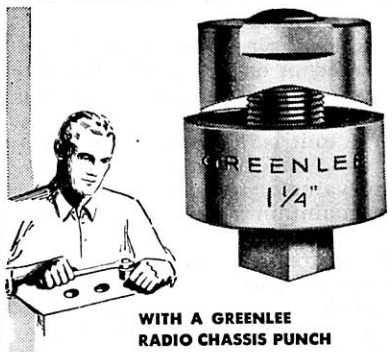
6A8GT	12BA6	1T4	39c each
6AT6	12BE6	1U4	
6BA6	12K7GT	1S5	
6BE6	12Q7GT	3S4	
6K7GT	12SA7	3Q4	
6Q7GT	12SK7	3V4	
6SA7GT	12SQ7	12AU6	
6SK7GT	25L6GT	12BF6	
6SQ7GT	25Z6GT	35B5	
6V6GT	35W4	35L6GT	
6X4	50B5	35Z5GT	
12A8GT	50L6		
12AT6	1R5		

SPECIAL OFFER! All 39c Tubes may be purchased in lots of 100 assorted, at $35.00 per 100.

6A7	6AU6	6G6G	49c each
6AC5	6BH6	6SN7GT	
6AK5	6BJ6	12AU7	
6AQ5	6C6	25Z5	
6AQ6	6D6	75	
6AJ5	6SL7GT	117Z3	
1H5GT	19T8	53	59c each
1N5GT	70L7	117L7	
32L7	84	6L6GA	

SPECIAL! 6BG6G, 89c
Standard Replacement
VOLUME CONTROLS, All sizes
1⅝" shaft, less switch, each 24c
With SPST switch, each 34c
With DPST switch, each 39c
PM SPEAKERS. Less Trans.
4" with Alnico V Magnet $1.14
5" with Alnico V Magnet 1.14
6" with Alnico V Magnet 1.49
3" PM with plastic cone, and 8-oz. Alnico V Magnet 1.35
6"x4" PM with Alnico V Magnet 1.19
WEBSTER AJ1 Pickup, plastic arm 1.49
SELENIUM RECTIFIERS
100 Ma. 59c
75 Ma. 49c
TERMS: Net C.O.D., F.O.B. N.Y.C. 35c Handling Charge on all orders under $5.00.
Write for Bargain Catalog N-11
GREYLOCK ELECTRONIC SUPPLY CO.
30 Church Street New York 7, N. Y.

CUT ACCURATE HOLES IN RADIO CHASSIS



WITH A GREENLEE RADIO CHASSIS PUNCH

● Make smooth, true holes quickly this easy way. Just turn GREENLEE punch with an ordinary wrench and have an accurately-sized opening for plugs, sockets, and other receptacles. No reaming or filing. A GREENLEE Punch for each of these sizes: ½"; ⅝"; ¾"; ⅞"; 1"; 1 1/16"; 1⅛"; 1 5/32"; 1 3/16"; 1¼"; 1⅜"; 1½"; 2¼". Also GREENLEE Knockout Punches and Cutters for conduit and meter holes up to 3½". Get facts now. Write Greenlee Tool Co., 1891 Columbia Avenue, Rockford, Illinois.

TOOLS FOR CRAFTSMEN
GREENLEE

The RECORDING and REPRODUCTION of SOUND

By
OLIVER READ
Editor, RADIO & TELEVISION NEWS
and
ROBERT ENDALL

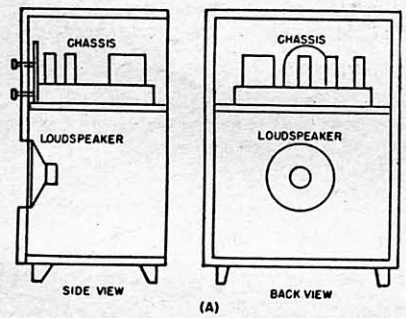
Part 22. Concluding article covering bass reflex cabinets, labyrinth cabinets, and infinite baffles.

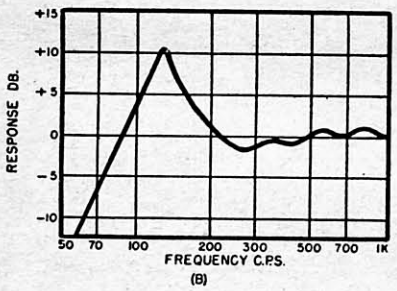
WITHIN the past few years there has been a continual improvement in all phases of sound communication and reproduction. Microphones, electronic circuits and communication systems, and phonograph recording and pickup techniques have been improved to the point where they are now capable of reproducing music and speech with practically no loss in quality from the original, and with the introduction of almost negligible noise and distortion.

The weakest link in the entire sound reproduction system at the present time is the manner in which the loudspeaker is used to reconvert the electrical energy into sound. The reason for this, of course, is that the correct use of the loudspeaker for best reproduction would involve considerable extra expense in the design and construction of commercial radios and phonograph reproducers, and the manufacturer prefers not to go to this additional expense if he can possibly avoid it. The general public must accept this inferior reproduction, since it is fairly expensive to purchase a good quality loudspeaker system and have it connected to some standard model radio receiver. However, the radio experimenter and technician need not accept poor reproduction, because a good loudspeaker system that will give performance practically equal to the other components of the audio reproduction system can be easily constructed at home at relatively little expense. The purpose of this article is to give data and design information which will enable the average radio technician to construct a loudspeaker system which will give the maximum performance that can be attained from loudspeakers at the present time.

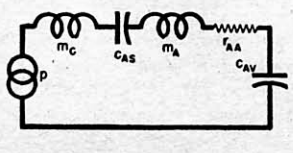
The common type of housing for loudspeakers is the conventional open-back cabinet which also contains the receiver-amplifier chassis and the phonograph mechanism. This arrangement is used in almost all receivers being sold at the present time, from the smallest table models to the large expensive consoles. In all cases the purpose of the cabinet is to provide a baffle for the loudspeaker, to prevent the sound from the back of the speaker cone (which is 180° out of phase with that from the front) from cancelling the sound transmitted from the front of the loudspeaker cone. When the sound path from the back of the speaker to the front is sufficiently long (as in the case of the large console cabinets) the low frequencies are reproduced; while in the midget radio cabinets the sound path from the back to the front is very small and the low frequencies are not reproduced because of the out-of-phase cancellation.

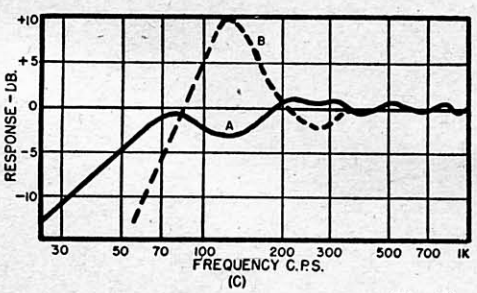
The most objectionable acoustical feature of such cabinets is the resonance in the enclosure behind the loudspeaker cone. The cabinet acts as an

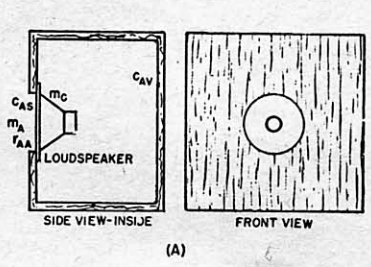




(Fig. 1)





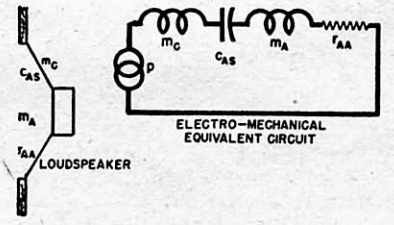


(Fig. 3)

Fig. 1. (A) Method of mounting loudspeaker in a standard console cabinet. (B) Frequency response characteristic obtained from conventional speaker-cabinet combination.

Fig. 2. The equivalent electro-mechanical circuit for most types of loudspeakers.

Fig. 3. (A) Totally enclosed loudspeaker cabinet. (B) Electromechanical equivalent circuit of this type of cabinet. (C) Typical frequency response of totally enclosed loudspeaker system (A). Curve B shows response when the back of cabinet is removed.



c_{AS} = ACOUSTIC CAPACITANCE OF SUSPENSION SYSTEM
m_A = INERTNESS OF AIR LOAD UPON CONE
r_{AA} = ACOUSTIC RESISTANCE OF AIR LOAD
p = FORCE GENERATED IN VOICE COIL/AREA OF CONE
m_C = INERTNESS OF CONE

(Fig. 2)

c_{AV} ACOUSTIC CAPACITY OF CABINET VOLUME
m_C INERTNESS OF CONE
c_{AS} ACOUSTIC CAPACITY OF SPEAKER SUSPENSION
m_A INERTNESS OF AIR LOAD UPON CONE
r_{AA} ACOUSTIC RESISTANCE OF AIR LOAD
p FORCE GENERATED IN VOICE COIL/CONE AREA

TYPE	POWER HANDLING CAPACITY	FREQUENCY RESPONSE (cycles)	WEIGHT	SPEAKER DIMENSIONS	ENCLOSURE REQUIRED	RECOMMENDED CABINET DIMENSIONS (Sloping front)
755A 8" direct radiator	8 watts	70-13,000	Speaker 4¾ lbs.	Dia.—8⅜" Depth—3⅛" Baffle Hole Dia.—7"	2 cu. ft.	Width—16" Height—21" Top Depth—9¼" Bottom Depth—12"
756A 10" direct radiator	20 watts	65-10,000	Speaker 10 lbs.	Dia.—10¼" Depth—3¼" Baffle Hole Dia.—8 15/16"	2½ cu. ft.	Width—19" Height—22" Top Depth—8⅞" Bottom Depth—11 13/16"
728B 12" direct radiator	30 watts	60-10,000	Speaker 17 lbs.	Dia.—12 11/32" Depth—3 25/32" Baffle Hole Dia.—11"	3 cu. ft.	Width—21" Height—23¾" Top Depth—9¼" Bottom Depth—12⅜"
754A 12" direct radiator	15 watts	60-10,000	Speaker 17 lbs.	Dia.—12 11/32" Depth—3¾" Baffle Hole Dia.—11"	3 cu. ft.	Width—21" Height—23¾" Top Depth—9¼" Bottom Depth—12⅜"

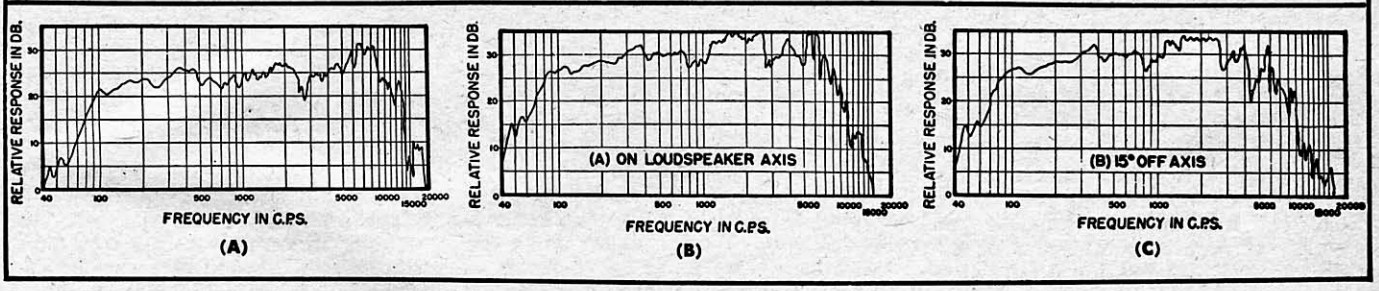


Fig. 4. Baffle requirements and dimensions for Western Electric 8, 10, and 12 inch speakers designed for use with totally enclosed cabinets. Frequency response curves shown are (A) for the Western Electric 8 inch (755A) speaker at a point on its axis; (B) and (C) for the Western Electric 12 inch (728B) speaker.

open-ended resonant tube (such as, for example, an organ pipe), and accentuates the loudspeaker response at its resonant frequency due to the increased efficiency of the acoustical system. This cabinet resonance causes a sharp peak in the response, generally in the range between 100 and 200 cycles, which very unfavorably affects the intelligibility and naturalness of the reproduced sound and is especially noticeable in the reproduction of music and male speech. This is the "boomy" quality which is so characteristic of almost all commercial radio receivers.

In addition to the "boomy" quality of the sound reproduction, the open-back loudspeaker cabinet has the following further disadvantages:

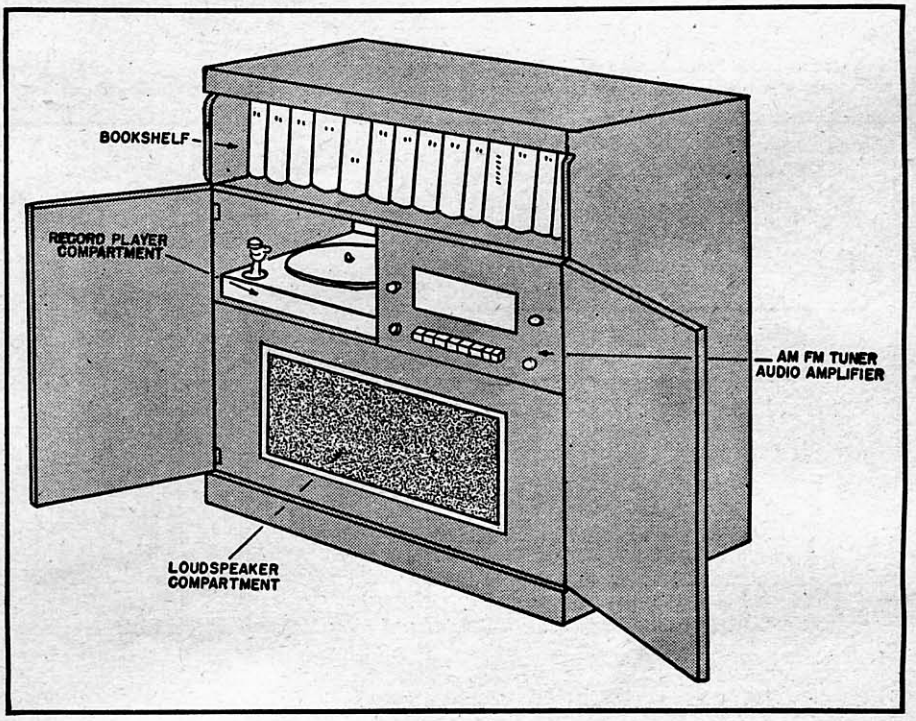
a. The loudspeaker has poor low-frequency response due to inadequate baffle area afforded by the cabinet.

b. There is insufficient acoustic damping of the loudspeaker diaphragm, resulting in overshooting of the moving system and consequent distortion.

c. Because of inadequate damping of the mechanical system, there is a large variation in the electrical impedance of the loudspeaker at its primary resonant frequency, which causes poor impedance matching and additional distortion in the output stage of certain types of amplifiers.

Electrical compensation in the amplifier frequency response to correct for the cabinet resonance is not entirely satisfactory, since it cannot damp the overshoot of the mechanical system on loud signals and does not improve the poor transient response which is characteristic of a system having such a peak in the response at one frequency. In addition, the peak in the response due to the cabinet resonance will change according to

Fig. 5. Sketch of a home-built radio-phonograph combination, using two RCA 7 inch accordion type loudspeakers housed in an infinite baffle enclosure.



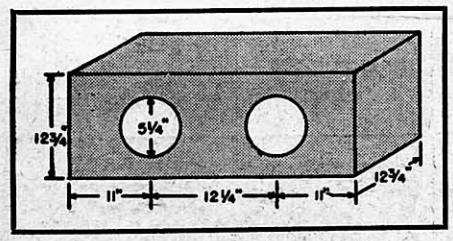


Fig. 6. Inside dimensions of infinite baffle loudspeaker enclosure of radio-phonograph unit shown in the sketch of Fig. 5.

whether the back of the cabinet is placed close against a wall, whether it is standing upon a bare hardwood floor or upon a soft rug, and with other such conditions of cabinet placement.

However, the above faults of the open-back cabinet loudspeaker mounting can be eliminated, and wide-range reproduction of sound with good frequency response and without undesirable peaks may be attained from loudspeakers by use of a properly designed housing for the loudspeaker. In general, proper design of a housing for best loudspeaker performance consists of incoporating acoustical networks in the cabinet to eliminate the faults of the open-back cabinet and to improve the loudspeaker characteristics.

The manner in which a loudspeaker cabinet may be made to act as an acoustical network to improve the speaker performance may best be understood by consideration of the electromechanical equivalent circuit of the loudspeaker as shown in Fig. 2. (It must be understood that this is not the electrical circuit of the loudspeaker itself, but is just an analogy by which the mechanical and acoustical properties of the loudspeaker are represented by electrical quantities.) Thus in this equivalent circuit the inductance m_C represents the mechanical inertia of the loudspeaker cone, the capacity C_{AS} represents the acoustic capacitance of the suspension system, and m_A and r_{AA} represent the inertia and acoustic resistance of the air load upon the cone. The pressure p of the generator in the acoustic system is the force generated in the voice coil divided by the area of the cone. Above the resonant frequency of this system the sound output is independent of frequency, while it falls off rapidly below resonance. The manner in which the acoustic network represented by the cabinet affects the response may be understood by considering it in relation to the loudspeaker equivalent circuit.

The simplest type of loudspeaker baffle is a cabinet with an enclosed back, as shown in Fig. 3A. By making the cabinet as rigid as possible and padding the inside with absorbent material, the sound from the back of the loudspeaker cone is completely prevented from reaching the front, therefore such a cabinet is sometimes known as an "infinite baffle" cabinet. The effect of such a baffle upon the loudspeaker response can be understood by reference to the electromechanical equivalent circuit shown in Fig. 3B. The cabinet volume has the effect of an acoustic capacity C_{AV}, which tends to lower the effective capacity in the circuit and raises the resonant frequency. The cabinet volume should, therefore, be made as large as is conveniently possible, so that it represents a large acoustic capacity and will have a minimum effect upon the resonant frequency of the system. It can be seen that the loudspeakers for which this type of cabinet is most suitable are those in which the resonant frequency is quite low, preferably in the neighborhood of 50 cycles or lower.

The frequency response of a typical "infinite baffle" loudspeaker system of the type shown in Fig. 3A and B is given in the curve labelled *A* in Fig. 3C. For comparison, the frequency response of the same system with the back of the cabinet removed is shown by the dotted curve labelled *B*. It can be seen from the curves that the use of the back-enclosed cabinet not only eliminates the peak due to cabinet resonance and gives a smoother curve, but it also extends the low-frequency response appreciably.

The "infinite baffle" cabinet may be used to good advantage with the *Western Electric* 8-inch, 10-inch and 12-inch loudspeakers (Types number 755A, 756A, and 728B) which have been designed for this type of enclosure, and with the *RCA* accordion-type loudspeaker which has a resonance of approximately 45 cycles. The baffle requirements of the *Western Electric* loudspeakers are given in the chart in Fig. 4, and the frequency response curves of the 8-inch and 12-inch loudspeakers are given below.

An infinite-baffle system which was built using two *RCA* 7-inch accordion-type loudspeakers is illustrated in Fig. 5. The dimensions of the loudspeaker encolusure are given in Fig. 6. However, these dimensions are not critical and were determined in this case by the dimensions of the cabinet which was already built.

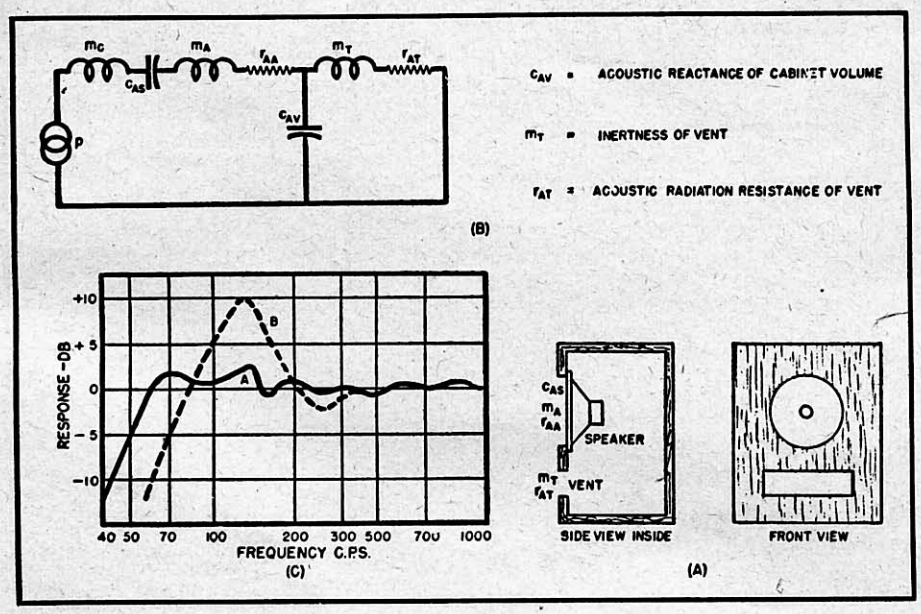
The infinite baffle type of loudspeaker mounting is widely used in commercial broadcast monitoring, where good quality of reproduction is essential. The system used in this case generally consists of a high-fidelity 12-inch loudspeaker mounted in a back-enclosed cabinet having a large front area (often as much as 6 ft. in width), and is mounted on a wall tilted at such an angle that the sound radiation is directed at the operator who is listening to the program.

Generally the low-frequency response of any loudspeaker is limited by the fact that the coupling between the cone and the air decreases at the very low frequencies. One of the methods of increasing the coupling is by using a large cone, which has the effect of increasing the radiation resistance. However, when the cone becomes too large the high-frequency response begins to decrease and additional expense is involved in attaining good high-frequency response. A simple and practical method of increasing the coupling to the air at low frequencies is by making the loudspeaker cabinet act as an acoustical network to perform this function. The manner in which this is generally accomplished is by causing the cabinet to act as a phase inverter so that the low-frequency radiation from the back of the cone may be added in phase with the sound from the front of the cone.

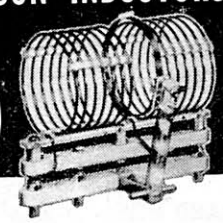
The simplest type of acoustic phase inverter is the vented box generally known as the "bass-reflex" baffle. It consists of a closed cabinet with an opening through which it is coupled to the air, and is represented by a capacity-inductance-resistance resonant cir-

(*Continued on page* 120)

Fig. 7. (A) Physical details of the bass-reflex loudspeaker cabinet. (B) Electromechanical equivalent circuit. (C) Curve A is a typical frequency response of a bass-reflex speaker system. Curve B is frequency response of an open-back cabinet having the same volume plotted on the same graph to facilitate comparison.



New JOHNSON INDUCTORS



MATCH
Coil to Tube
Link to Line

JOHNSON'S new and comprehensive line of inductors and "plug-in" swinging link assemblies bring to the amateur the same efficiency achieved in commercial and broadcast components.

This efficiency is secured by the use of two fundamental types of inductors for each band—inductors for use with either high voltage low current tubes or inductors for use with low voltage high current tubes. Each of these models is available in 150, 500 and 1,000 watt ratings.

Another great feature is the matching of "plug-in" link to feed line. The new JOHNSON Inductor Catalog provides the information necessary to select the "plug-in" link that will best match a particular inductor to any feed line ranging from 50 to 600 ohms impedance.

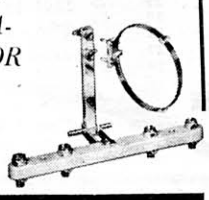
A complete line of semi-fixed link inductors is also available.

All inductor components, including hardware, are spaced to fit conventional, present day jack and plug assemblies in their respective ratings and can be purchased individually.

You'll find that the new matched JOHNSON coils and "plug-in" links will put substantially more RF in your antenna.

See them at your dealer or write for new

JOHNSON AMATEUR INDUCTOR CATALOG



E. F. JOHNSON CO.
WASECA, MINNESOTA

Recording of Sound

(*Continued from page* 50)

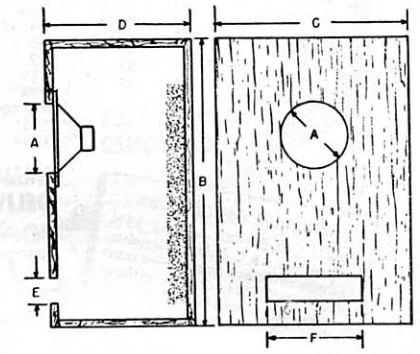
cuit as shown in the electrical equivalent circuit of Fig. 7B. The design conditions which have been found to give satisfactory results in the design of such baffles are that; *a.* the resonant frequency of the vented enclosure should be approximately the same as that of the loudspeaker, and *b.* the aperture or area of the vent should approximate the effective radiating surface of the loudspeaker. When the cabinet and vent dimensions are suitably chosen, the sound radiated from the vent is practically in phase with that from the loudspeaker, so that the low-frequency response is extended and a smoother frequency response characteristic is obtained. The frequency response of a typical bass-reflex loudspeaker system is shown in curve *A* of Fig. 7C; for comparision, the frequency response of the loudspeaker in an open-back cabinet having the same volume is shown by the dotted curve labeled *B*.

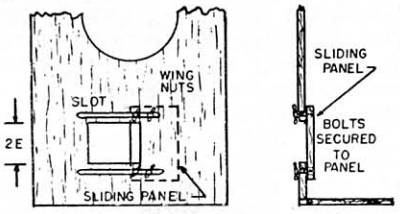
The bass-reflex loudspeaker cabinet is widely used in high-quality sound reproducing systems. It is being used commercially with excellent results with loudspeakers ranging in size from 8-inch to the large 18-inch low-frequency units of dual systems of the type used in theaters and auditoriums. It is also one of the most satisfactory types of loudspeaker enclosure for home construction, since it is quite simple to construct and lends itself easily to modification to compensate for variations in speakers and in listening conditions. The chart in Fig. 8 gives the various physical values and dimensions for the design of bass-reflex cabinet for any of the good standard and high-fidelity 8-inch, 10-inch, 12-inch and 15-inch loudspeakers in general use at the present time. The drawing which accompanies the chart in Fig. 8 also shows the manner in which the resonant cabinet characteristics may be adjusted to compensate for listening conditions.

The listening conditions in most living rooms are far from ideal, since various factors such as the distribution of furniture, rugs and draperies, the size and shape of the room, the reflective and absorptive capacity of the various exposed surfaces, and the position of the loudspeaker in the room will affect the listening conditions appreciably. In many cases the ideal flat, linear response may not be the most desirable, and certain corrections should be made in the frequency response to compensate for the room characteristics. When a bass-reflex baffle is used, this may be done

Fig. 8. Dimensions for constructing a bass-reflex loudspeaker cabinet. Note that the housing is to be made of rigidly constructed ¾ inch plywood with felt padding behind speaker.

LOUDSPEAKER SIZE	TYPICAL COMMERCIAL LOUDSPEAKERS	OPENING A	OVER-ALL CABINET DIMENSIONS B	C	D	VENT DIMENSIONS E	F
8 INCH	Jensen P 8 SH General Electric S800D, S810D, S818D Utah SP 8 JW	6½" diam.	23"	17¾"	10¼"	3"	9¼"
			Enclosed volume = 2800 in.³			Area = 28 in.²	
10 INCH	Jensen P 10 SH General Electric S1001D	8½" diam.	28½"	22"	12½"	4"	12½"
			Enclosed volume = 5700 in.³			Area = 50 in.²	
12 INCH	Jensen P 12 SH General Electric S 1201 D Utah SP 12 LW	10½" diam.	34"	26"	14¾"	5¼"	16½"
			Enclosed volume = 10,000 in.³			Area = 86 in.²	
15 INCH	Jensen P15-NH, JAP-60, JHP-52	13¾" diam.	41"	30½"	17¼"	7¼"	21"
	RCA LC-1A	15⅝" diam.	Enclosed volume = 16,200 in.³			Area = 150 in.²	





Details of the sliding panel by which the vent opening in the bass-reflex cabinet may be adjusted in order to change the resonant frequency of the cabinet unit.

FIRST TELEVISION OPPORTUNITY OF ITS KIND EVER OFFERED

$140.60 Worth of Components for

630 TS SALE PRICE $39.50

All Brand New in Sealed Cartons

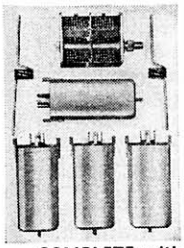
Part No.	Description	List Price
201/D1	DEFLECTION YOKE	$ 13.75
201/R1	WIDTH CONTROL	1.30
201/R3	HORIZONTAL CONTROL	1.40
201/T6	POWER TRANSFORMER	50.00
201/X1	YOKE MOUNTING HOOD	2.75
204/L1	FILAMENT CHOKE	.30
204/T2	TRANSFORMER, vertical output	9.00
204/X2	VIDEO and I.F. KIT	35.00
208/T2	TRANSFORMER, vertical blocking	5.70
208/T3	TRANSFORMER, horizontal blocking	4.55
211/T1	TRANSFORMER, horizontal output	16.85
	Total List Price	$140.60

ALL FOR **$39.50** COMPLETE

TELEVISION and FM WIRE

CO-AX CABLE,	RG59U,	100 ft.	$ 5.25
CO-AX CABLE,	RG59U,	500 ft.	24.75
TWIN LEAD-IN,	300 ohm,	100 ft.	1.95
TWIN LEAD-IN,	300 ohm,	500 ft.	7.95
TWIN LEAD-IN,	300 ohm,	1000 ft.	13.75

FM CONDENSER & COIL KIT (88 to 108 Mc)



- Variable Condenser
- Discriminator Coil
- Oscillator Coil
- Two I.F. Coils
- Limiter Coil
- Antenna Coil

This Kit contains the vital parts needed to build an FM Tuner or Radio and for modernizing Pre-War FM Sets; all other parts needed are standard.

$4.95

COMPLETE with instructions and diagram

TELEVISION TUBULAR CONDENSERS

.05 —2500V	$0.58	.01 — 5000V.	.74
.1 —2500V	.64	.05 — 5000V.	.74
.25 —2500V	.86	.0005— 7500V.	.58
.05 —3000V	.69	.003 — 7500V.	.67
.003—5000V	.57	.005 — 7500V.	.72
.005—5000V	.62	.0005—10000V.	.64

RADIO TUBES—BRAND NEW

1LD5, Sylvania	$0.39
1LN5, Sylvania	.39
6AC7, R.C.A.	.79
6AG5, Philco	.79
6SC7, Kenrad	.55
6SL7, Philco	.59
6SN7, R.C.A.	.59

BROOKS RADIO DIST. CORP.

80 VESEY ST., DEPT. B, NEW YORK 7, N. Y.

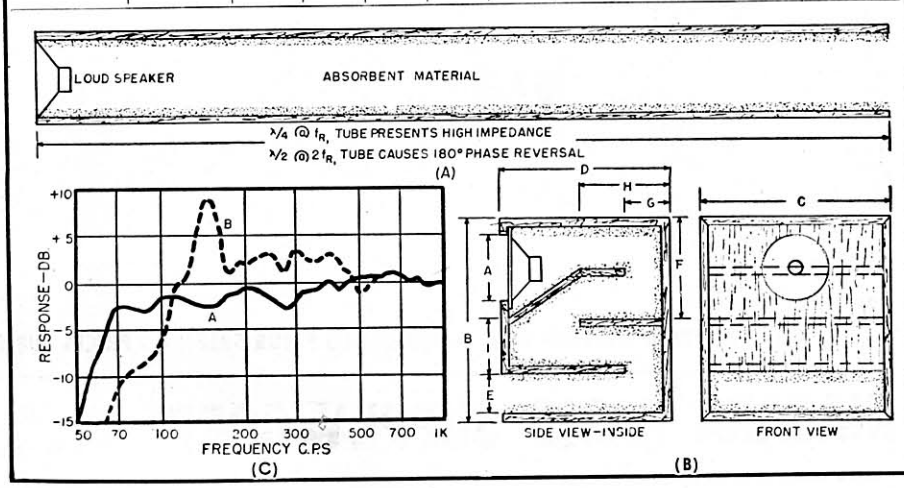
directly in the loudspeaker system by use of the method shown in Fig. 8. By making the vent in the box adjustable as indicated, the resonant frequency of the baffle may be adjusted over a wide enough range to make the necessary compensations in the low frequency response of the loudspeaker. Once the speaker is installed in its cabinet and placed in its normal position in the room, the adjustment of the desired opening is best done by ear until the response of the system sounds best for such program material as a broadcast of a symphonic orchestra or the reproduction of good records.

Another type of resonant phase inverter cabinet makes use of the distributed constants of a line instead of using the lumped constants of the bass-reflex vented box. The method of using a resonant line instead of lumped inductance and capacity is probably familiar to anyone who has done any work or experimentation in radar or in ultra-high-frequency amateur communication, where parallel lines and coaxial lines are used as tuned circuits instead of using the standard lumped inductance-capacity tuned circuits which are used at lower frequencies. The same method may be used in the design of acoustic resonant circuits for use with loudspeaker baffles. The manner in which this is accomplished is illustrated in Fig. 9. An absorbent-walled tube is coupled to the back of the loudspeaker at one end, and is open to the air at the other end. At the frequency for which the tube is one-quarter wavelength long, the tube sees a low impedance at the open end and therefore presents a high impedance to the back of the loudspeaker cone. Thus, by choosing the length of the tube so that it is a quarter-wavelength at the resonant frequency of the loudspeaker suspension, the resonance of the speaker is damped in the same manner as with the bass-reflex cabinet. At double the resonant frequency, the tube is a half-wavelength long and the phase is reversed, therefore the sound through the tube is in phase with that from the front of the loudspeaker and the response is increased. The tube lining absorbs almost all of the sound above about 150 cycles, therefore the higher resonances have no effect.

The principle of the resonant acoustic tube is adapted for use as a loudspeaker baffle by folding the tube in the manner shown in Fig. 9B so that the total outside dimensions are practical for use as a cabinet in the home or studio. A loudspeaker cabinet of this type is known as an "acoustical labyrinth." In general the cross-section of the tube is approximately the same or a little smaller than the effective radiating area of the loudspeaker. Fig. 9 gives the various values and physical dimensions for the design and construction of "labyrinth" baffles for the same loudspeakers which are given with bass-reflex cabinets in Fig. 8. The precise manner in which the tube is folded to form the

Fig. 9. Dimensions for constructing labyrinth loudspeaker cabinets. (A) Method by which a resonant tube is used to improve loudspeaker performance. (B) Labyrinth speaker cabinet formed by folding the resonant tube. (C) Curve A is a typical frequency response of a labyrinth loudspeaker system. Curve B is the frequency response of the corresponding open-back cabinet system for comparison. Note: In assembling, be sure to nail and glue all joints securely. Front may be screwed on.

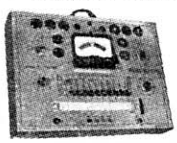
LOUD SPEAKER SIZE	SPEAKER OPENING	OVERALL CABINET DIMENSIONS			PARTITION POSITIONING					MATERIAL
	A	B	C	D	E	F	G	H	I	
8 INCH	6½" diam.	17"	14"	11½"	3"	9½"	2½"	5"	3¾"	½" plywood ½" felt padding
10 INCH	8½" diam.	21¾"	17"	14"	4½"	10½"	4"	5"	3"	¾" plywood ¾" felt padding
12 INCH	10½" diam.	27¾"	21"	16¾"	6"	13½"	5¾"	6¼"	5"	¾" plywood 1" felt padding
15 INCH	.....	35"	25"	21"	7"	18"	6½"	7½"	4"	¾" plywood 1" felt padding



WHERE TO BUY IT.....
WHOLESALE RADIO
of Baltimore

Make it an Electronic Gift—

The G-E Model YTW-1
TUBE & BATTERY CHECKER
Will Exceed Your Expectations!
Only $49.50

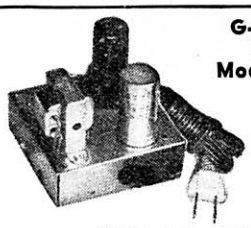


Checks all the newest tubes, quickly and accurately. Roll scale chart, quick short test, large fused meter (4⅝" x 4⅛") in a durable steel portable case. G-E Quality throughout.

Treat Yourself to True Value, Fidelity and Efficiency

Brilliant G-E 1201
FOR CUSTOM INSTALLATION
Deluxe 12 inch Alnico V
14.5 oz. P.M. Speaker
50-13,000 Cycles
25 WATTS
$17.70





G-E PHONO PREAMP
Model UPX-003
with Self-Contained Power Supply
$9.57

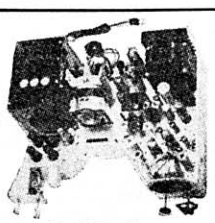
110 V. A.C. 60 Cycles
FOR USE WITH
VARIABLE RELUCTANCE PICKUP
Standard Model RPX-010.....$4.77
Micro-Groove Model RPX-041.....5.97

First! By Popular Demand!



MEISSNER
Model 8C
FM-TUNER
$38.33

Famous
RCA 630TS 10"
TV RECEIVER
IN KIT FORM



$205.00 (Less Cabinet)
Complete with 30 tubes including 10" picture tube—Step by step instructions—Front end pre-wired—Vital channels pre-aligned—All sockets and other important parts assembled to chassis.
TV Cabinet for RCA 630TS—$33.75

WRITE DEPT. QR-73 TODAY FOR OUR FREE MONTHLY "FYI" BULLETIN
Phone—MUlberry 2134

WHOLESALE RADIO PARTS CO., Inc.
311 W. Baltimore St.
BALTIMORE 1, MD.

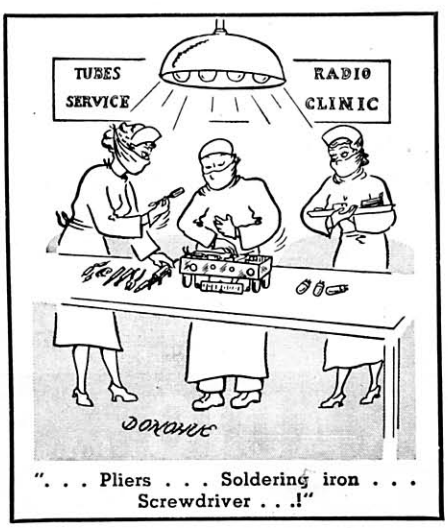
labyrinth baffle is not important as long as the length and the cross-sectional area are correct, therefore the tube may be folded in any manner which fits the individual requirements. The design data which is given in Fig. 9 covers just one of the many ways in which the tube may be folded.

The author has constructed a labyrinth baffle of this type using a *Jensen* 8-inch high-fidelity loudspeaker (type No. PM8SH) which has given excellent results. It has been tested by listening comparison with various high-quality loudspeaker systems, and has been found to be almost indistinguishable from some of the best of the expensive studio monitoring loudspeakers even at very loud home-listening sound levels.

The labyrinth type of loudspeaker enclosure has the advantage over the bass-reflex cabinet that for the same loudspeaker it occupies a considerably smaller space. The bass-reflex cabinet has the advantage that it is simpler and less expensive to construct, and can be tuned over a certain frequency range by adjusting the vent opening. Therefore the choice of which type of loudspeaker baffle to use in any specific case depends upon the individual requirements. If space is not an important factor and expense is, then the bass-reflex cabinet is best to use. If space is limited, then the acoustical labyrinth cabinet should be used. If a loudspeaker with a low resonant frequency is used, then the infinite baffle cabinet can be used to good advantage.

When a good loudspeaker is used in the proper type of baffle according to the information given in this article, the listener will be able to obtain remarkable naturalness and clarity of sound reproduction which is at the present time attained only by the most expensive commercial loudspeaker systems.

"The Recording and Reproduction of Sound" has been based on material from the author's book "The Recording and Reproduction of Sound" to be published by Howard W. Sams & Co., Inc., 2924 East Washington Street, Indianapolis 6, Indiana. —30—



". . . Pliers . . . Soldering iron . . . Screwdriver . . .!"

IRC Power Wire Wounds are better built every step of the way



Starting right from the winding form IRC Power Wire Wounds combine the best of materials, workmanship and resistor "know-how".

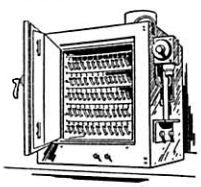
Highest grade alloy wire uniformly wound on sturdy ceramic tubes. Terminals spot welded for security; heavily tin dipped for easy soldering.





Climate-proof cement coating provides dark, rough surface—best for rapid heat dissipation, moisture protection and ability to withstand reasonable overloads.

Resistors cured at LOW temperature prevents damage to resistance windings, and loss of temper in terminals. Bands for adjustable types feature stainless steel springs and silver contacts. Cannot corrode to cause high resistance.







For exacting, heavy-duty requirements you can rely on IRC Power Wire Wounds for balanced performance in every characteristic. Being full-sized, they can operate continuously at full rating. Derating in high ranges is unnecessary.

IRC Power Wire Wounds are available in a full range of ratings, sizes and terminal types. 91 new ranges have just been added. Next time you step up to your distributor's counter—stock up on IRC Power Wire Wounds.

IRC INTERNATIONAL RESISTANCE CO.
401 N. Broad Street, Phila. 8, Pa.
In Canada: International Resistance Co., Ltd., Toronto, Licensee



YES! We're listed in the RED BOOK
Looking for the correct IRC replacement controls for any receiver manufactured from 1938 to 1948? Just refer to the Radio Industry RED BOOK!

THE RECORDING and REPRODUCTION of SOUND



Fig. 1. Hand cranked, governor controlled Victrola of the year 1898.

By
OLIVER READ
Editor, RADIO NEWS

Part 2. The history of "acoustical" recording machines and the transition to our present-day so-called "electrical" recording heads of the capacitive, magnetic, and crystal types.

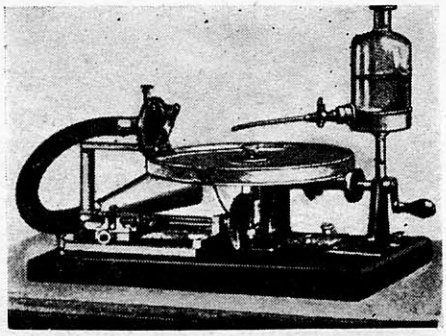
THE great American inventor *Thomas Edison,* back in 1877, stumbled across what was to become the first recording and reproducing system. Edison used an *acoustical* method for recording and reproducing sound on a wax roll. Commercial use was not found for this invention until several years later when the *Ediphone,* a business dictating machine was developed. Correspondence and other intelligence could be recorded on this unit and later transcribed from the wax cylinders. The early models utilized cylinders which could be used only once, but later ones were developed with a very thick coating of wax so that previous sounds could be scraped from the surface and the new surface reused.

The record industry had its origin in 1855 with Leon Scott's "Phonautograph." This was not a practical means for recording or reproducing sound as about all this machine could do was to trace grooves in lampblack.

The granddaddy of the present *Dictaphone* (shown in Fig. 3) machines was invented by *Alexander Graham Bell* and two associates in 1881. His machine employed a heavy metal casting to which was mounted a heavy steel rod, part of which acted as a "feed screw" to move the acoustical diaphragm in a horizontal plane. A wax coated cylinder was also mounted to the shaft which, on Bell's invention, was hand-driven by a crank. This historic machine was removed from its vault in the Smithsonian Institute on October 27, 1937 where it had remained for 56 years. The wax cylinder when replayed revealed the following:

"The following words and sounds are recorded upon the cylinder of the gramophone . . . tra tra . . . There are more things in Heaven and earth, Horatio, than are dreamed of in our philosophy . . . trr . . . I am a gramophone and my mother was a phonograph."

Fig. 2. Berliner's original machine which featured the use of wax disc.



Later in 1885 the Volta Laboratories, controlled by Alexander Graham Bell, began filing new patents to make the invention commercially successful. The *American Gramophone Company* was organized in order to serve a market for these machines. Edison then began to exploit his machine commercially.[1]

There were a few patent difficulties between Edison and Volta. However, when these were worked out, they became very friendly competitors in this new field.

Emil Berliner then came into the picture and to him goes credit for the records and phonographs we use today. Berliner devised a means for recording on and reproducing sound from a flat disc. (Fig. 2.) Furthermore, he developed a means for pressing (making copies) records from a master, rather than taking a chance of ruining the original disc, as was done by Edison and Volta. Berliner later became connected with a Camden machinist by the name of *Eldridge Johnson.* Johnson contributed many improvements to the original Berliner machine.

The Edison and Bell machines both worked on the same fundamental principle. In both cases, the waves set up in the air by any source of sound were allowed to strike a delicately held diaphragm which vibrated under the impact of the sound waves. The only difference was in the method of re-

[1] Walker, Frank B. RADIO AGE. January 1942.

cording the sound on the rotating cylinder. In the Edison invention, the record was produced by indenting a line of varying radial depth, while Bell obtained the record by actually cutting the line on a blank cylinder. In both cases the vibrating diaphragm was made to produce a sound line of varying depth on the surface of the record.

Berliner, in 1890, took out patents for further improvements in the Gramophone. In particular were new forms of diaphragm holders or sound boxes. One was designed for recording purposes and the other for reproducing. Even then the Gramophone had not become a commercial article. It was near the end of 1897 that the first disc record was manufactured commercially in the United States. This made the Gramophone popular as a means for entertainment. Instead of a record being made from an etched metal original, a disc record made by a new process which allowed many hundreds of good facsimile copies to be made from the one master record could be offered to the public. The process consisted of cutting the first record on a disc-shaped blank of a wax-like material. Later a solid metal negative was made by electro-deposition. Then followed the pressing of copies of the original from this negative in a material which was hard at normal temperatures but became plastic under heat.

The period that followed was devoted by several inventors to mechanical improvements for the machine. An efficient governor, or speed regulator, was provided to insure a uniform speed of rotation of the turntable. The hand-driven machine was abolished and a new machine which was driven by a spring motor substituted. The speed regulator was furnished with an indicator that showed the speed when the machine was running so that the records, on reproduction, could be revolved at exactly the same speed as the blank on which the original record was cut.

The sound box also went through a series of improvements, the inventors' object being to render the diaphragm as sensitive as possible, either to the sound waves of the selection being recorded or to the vibrations transmitted to it from the record disc, as the case might be. Other improvements were made in the means of conveying the sounds recreated in the sound box to the ear of the auditor. The old air tube had disappeared to give place to a small horn. The sound box was attached to the narrow end. The next step was to remove the amplifying horn a short distance from the sound box and to carry it upon a rigid bracket on the cabinet of the instrument. The sound box was connected to the small end of the horn by a piece of flexible tubing which allowed the sound box to move across the turntable and also to be raised or lowered above the record. Patents were taken out in 1903 to replace this piece of tubing with a paper arm. A joint in the amplifying horn itself was also added. The idea was that while the horn could be located immediately next to the sound box, the latter could be moved with freedom without moving the heavy bell portion of the amplifying horn. The success of this invention was immediate and a tapering sound arm was adopted.

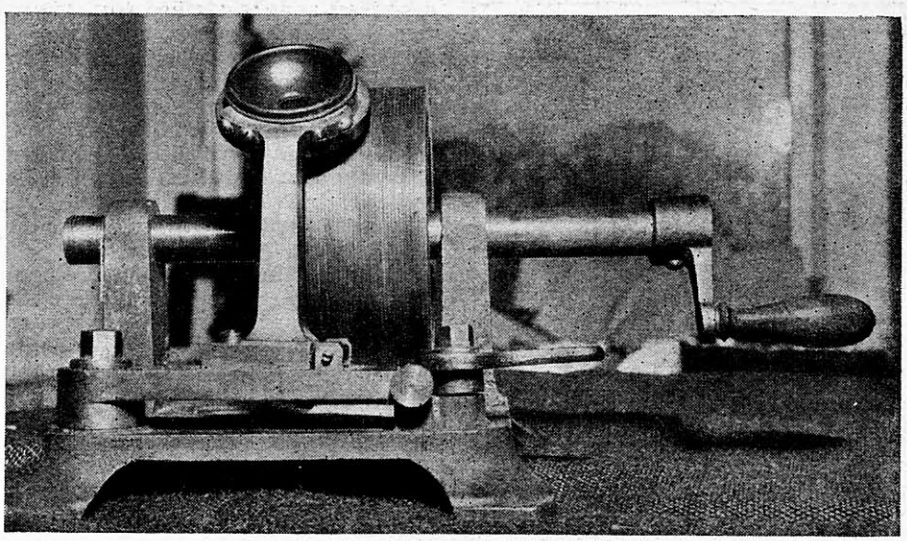


Fig. 3. The original Bell Gramaphone (1881) now in the Smithsonian Institute.

The Auxetophone

Sir Charles Parsons, English inventor, did much development work on the Gramophone. He perfected means for intensifying the sound by using air valves. Improvements in sound reproducers or intensifiers (as they were then called) applicable to phonographs, Gramophones, telephones, etc., were replaced by Parsons with the well-known mica diaphragm and by a very finely adjusted valve which controlled the flow of a column of air supplied under pressure. (Fig. 4). The action of Parsons' invention which he called the *Auxetophone,* was as follows: As the needle followed the sinuosities of the sound line on the record, the valve moved with it and this opened and closed the slots in the valve seat through which the air was rushing. The air was therefore given minute pulsations corresponding to the undulations in the sound record so

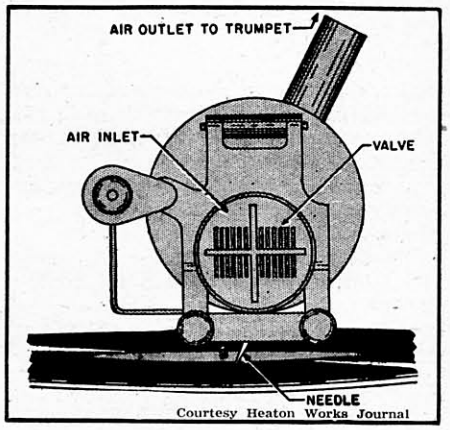


Fig. 4. Construction details of Parson's Auxetophone designed for intensifying sound by means of air pressure.

Fig. 5. Horn-style Victrola which was introduced to the public in the year 1902.



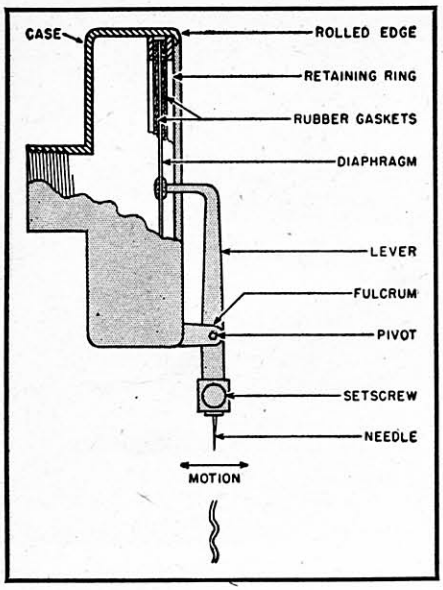


Fig. 6. Construction of an acoustical reproducer used with early phonographs.

that sound waves identical with those originally recorded were set up in the surrounding air and travelled to the ear of the hearer. The valve was mounted on a weigh bar rigidly connected to the reproducing stylus bar or needle holder. This weigh bar was capable of oscillating rotationally only about its own axis. A box containing a filter was also provided to insure that the air, before entering the valve, was perfectly clean. Very fine adjustments of the valve would be unbalanced if particles of dust or oil got into the unit.

Later patents taken out by Parsons related to musical instruments. Patents described the use of a valve as adapted to stringed instruments such as a violin, violoncello, bass, double bass, pianoforte, harp, etc. He replaced the usual sounding board or membrane by a valve operated directly by the vibrations of the strings. The valve was substantially the same as previously described and, as applied to a violin, was supported from a structure on which the bridge was carried, the sounding board being removed. On the exit side of the valve an expanding trumpet was provided and this was lined with velvet which had the effect of damping out any scratching sounds and very high harmonics.

Parsons' further contributions to the art included means for attaching Gramophone needles to the sound reproducer. He made the hole for the needle diamond shaped so that when in use the needle seated itself in the hole by the pressure between the socket and the record. To retain the needle in position when the reproducer was not resting on the record he provided a small magnet with its poles sufficiently near the needle to keep it in a slanting position. Alternatively, instead of using a magnet, a very light spring attached to the socket arm was used pressing lightly against the needle to keep it from falling out.

Parsons took out other patents that contributed further to improvement of sound quality. One of these patents covered the use of an elastic connection joining the needle and the moving part of the valve. The object of this invention was to provide means whereby scratching sounds and changes of tone were reduced or eliminated. A better and more uniform reproduction of the original sound resulted. He also took out a patent covering the use of a compensating cylinder and piston which rendered the working position of the valve independent of fluctuations of air pressure. It was found that the mean position of the valves was disturbed by differences or fluctuations of air pressure from the supply with the result that the tone or power of the instrument was thereby affected.[2]

The *Victor Talking Machine Company* was formed in 1898. One of the earliest of all the *Victrolas* is shown in Fig. 1. This was the old-fashioned acoustical horn style phonograph so familiar to many of our parents and grandparents.

[2] Heaton Works Journal, Dec. 1934—p. 251.

It should be remembered that all of the previous instruments described are essentially acoustical in operation. They relied almost entirely upon sound pressure, or pressure striking a diaphragm, (Fig. 6) and actuating a needle or other device. A typical recording setup of an orchestra making an acoustical record is shown in Fig. 7. Here we see that the musicians are literally crowded in front of a long horn. The weaker instruments, those having the lowest amplitudes of sound, were placed forward, while those possessing greater power, volume or amplitude were placed further to the rear. The idea was for the musicians to play as loud as possible in order that the greatest possible volume would enter the horn.

At the smallest terminating point of the horn was stretched a diaphragm in a framework. The diaphragm picked up the sound pressure waves coming into the horn from the instruments of the orchestra and the sound waves were modulated onto the master record of wax (Fig. 8). A reversed process was used for playback.

While the literature does not disclose why the standard speed of 78 r.p.m. was chosen for the phonograph industry, apparently this just happened to be the speed created by one of the early machines and, for no other reason continued to be used. In those early days speed was an important factor in getting satisfactory quality from the records. The phonograph turntable had to revolve at considerable speed in order that the high notes (and there were few in those days) could be reproduced, a process which will be explained in later articles. Finished records were reproduced by means of another horn connected to a diaphragm to which was fastened the reproducing needle. Sound waves appearing in the grooves of the record would move the needle from side to side and thus transmit vibrations to the diaphragm as shown in Fig. 6. Sound waves would then pass through the horn and be amplified somewhat by the "focusing effect" of the horn.

Thus, we have the earliest acoustical recording and reproducing systems. Today, as we all know, electronics plays a dominant part in the recording and reproduction of sound. The fundamentals, however, remain basically the same. Undulations in recorded grooves are transformed into electrical vibrations which are amplified by means of suitable amplifying equipment and reproduced through modern speaker systems.

Fig. 7. Rosario Bourdon and the Victor Salon Orchestra recording in the early '20's.



Electrical Recording

Electrical recording was borrowed from the radio, the microphone and the vacuum tube amplifier which had, by 1927, supplanted the old method of singing, talking or playing directly into a horn. This latter system depended upon the sound wave pressure

(*Continued on page* 149)

to activate a diaphragm and needle to do the cutting.[3]

In the early acoustical system, which was far from perfect, most of the harmonics and overtones were completely lost and even some of the fundamental waves, especially the low, or bass notes, failed to register. The adoption of the microphone amplifier and an electrically operated cutting stylus overcame most of the problems. The result was the production of much better records.

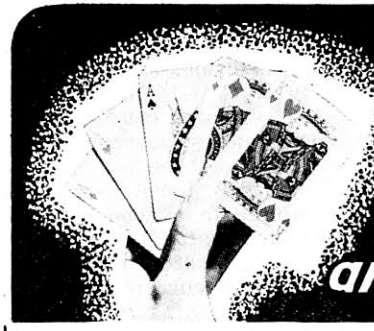
The earliest forms of electrical pick-ups were of the *carbon* or *magnetic* types. In 1927 a new pickup was introduced which relied on the *capacity* effect of its elements. Both the carbon and the magnetic types of pickup, although superior to the old acoustical pickups were far from perfect and their faults were many. For instance, in the carbon type the instability of the carbon granules caused a fuzzy blowing sound. These carbon granules soon became packed when electrical current passed through them and they would adhere to one another. In addition, the modulated electrical current was far from being an exact duplicate of the sound waves that were cut on the record.

In the magnetic type there was the problem of inertia from the relatively heavy iron armature which was held by a stiff spring to overcome the magnetic pull of the pole pieces and to prevent the armature from "freezing" to one of the pole pieces. Thus the inertia of the heavy iron armature and the tension of the spring made it very difficult for the instrument to respond to the delicate harmonics and overtones. The natural frequency of vibration of the armature, which was in the audio range, caused a blasting on certain notes. Furthermore, the energy generated by the movement of the armature to and from the pole pieces was in direct proportion to the square of the distance of travel. That meant that the current output was distorted relative to the sound waves cut on the record. It should be pointed out that the modern magnetic pickup has overcome these difficulties.

The Capacity Pickup

The new capacity or "modulator" pickup, as it was then called, is illustrated in Fig. 9. The diagram briefly explains the system. The first tube is oscillating at a frequency governed by the inductances of L_1 and L_2 and the capacity, C. Any conventional oscillating circuit may be used with this pickup. Inductively coupled to the oscillating coil is a pickup coil, L_3, which is in series with a capacity type pickup and C_1 — C_2 and a radio frequency transformer, *R.F.*, which is

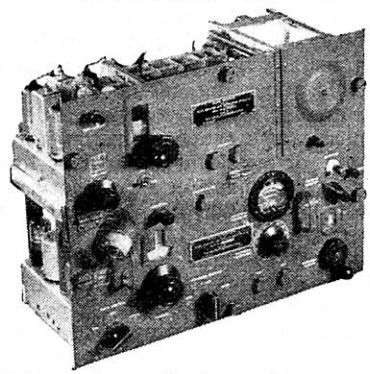
[3] Jewell, F. A., "Combining the Phonograph and Radio," RADIO NEWS, April, 1927, page 1238.



A SWELL DEAL IN PARTS and EQUIPMENT

CLOSING OUT REMAINING STOCK!

Portable Voice and Code Radio RECEIVER-TRANSMITTER



BC-654-A is a combined transmitter and receiver designed for portable or vehicular operation. The frequency range of both transmitter and receiver is continuous from 3700 to 5800 kilocycles; all stages gang tuned by anti-back lash worm gear dial mechanisms.

Use it for
- PARTS
- TUBES Worth $35 List
- TRANSMITTER
- RECEIVER

CLOSE-OUT PRICE . . . $14.95 as is less dynamotors

One-third deposit with order, balance C.O.D., F.O.B. shipping point.

RUSH YOUR ORDER!

CRYSTAL KITS
for added profits on your service business

A new modern xtal cartridge steps up performance on those old phonographs. Order today for extra profits.

ASTATIC CRYSTAL KIT
Kit contains 5 crystals and covers 80% of all requirements.
List Price $30.00
Your Cost 16.95
Your Profit $13.05

RCA CRYSTAL KIT
Contains 6 crystals and will cover 95% of all requirements.
List Price $31.00
Your Cost 18.60
Your Profit $12.40

ASTATIC-WEBSTER CRYSTAL KIT
Contains 13 crystals that will cover 95% of all requirements.
List Price $69.25
Your Cost 38.95
Your Profit $30.30

Get Acquainted Offer!
½" FRICTION TAPE—Half-pound rolls
Per Roll 7c—5 for 25c

TEST EQUIPMENT

RCA 162-C Chanalyst	$162.50
RCA 170-A Audio Chanalyst	345.00
RCA WV75-A High Frequency VTVM	125.00
Jackson VTVM	75.00
Triplett 2405 Multimeter	58.50
Triplett 2432 Signal Generator	88.50
RCP705-A Signal Generator	49.50
Speco Signal Tracer, AC Model	49.50
McMurdo Silver Signal Tracer	39.90

BC-645—VHF IFF RECEIVER-TRANSMITTER

Ideal for converting to high frequency receiver-transmitter.
A 15-tube Interrogator Transponder designed for airborne use. It will operate from either a 12VDC or 24VDC power source when used with the PE-101 dynamotor. The receiver is fixed tuned to 470 mc. Can be made to tune in the 425 mc. to 450 mc. amateur band.
Ask for conversion instructions and schematics. $17.95

BC 312 RECEIVER 9 tube superheterodyne $49.50

RME45 RECEIVER Complete $198.70

"Best Buys" in

PARTS

PE-103-Dynamotor (Cash only with order)	$7.50
Brush Crystal Headphones, Model A	7.20
Brush Vibrominke	10.29
Clarkstan Needle Pressure Gauge	1.80
Clarkstan Ring Tuner (2-meter band)	4.80
Model P Battery Eliminators	9.00
50L-6 Output Transformers	.75
Push Pull 6F-6 Output Transformers	.90
Universal Replacement Loops	.71
Replacement Line Cords, 6 foot lengths	.17
T.A.C. Model CP510 Professional Speed Key	6.75
Single Contact Female Mike Connector	.23
Single Contact Male Mike Connector	.21
Vertrod No. 10 Antennas	3.30

RG-8-U CABLE
Flexible Coax

Impedance 52 ohms. Maximum operating voltage, 4000 volts.

1 to 100 feet, per foot	$ .08
100 feet and up, per foot	.05½
18/2 SV Cord, 250 foot roll	8.75
Rubber covered lead-in wire, foot	.01
RCA Bright Vision Television Wire, foot	.05
Hank Wire, AC-DC, per hank	.18

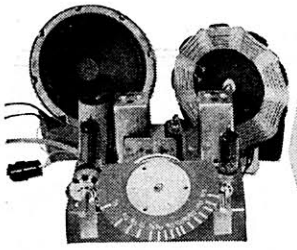
COMMUNICATIONS RECEIVER
R-45/ARR-7 (New)

Receives AM, MCW, and CW signals, frequency range 550 KC to 42.0 MC in six bands. Circuit features include both crystal and I.F. selectivity control, phasing control, automatic noise limiter, and an "S" meter. Furnished complete with handsome black metal cabinet with carrying handle, tubes and crystal. $150.00 less power supply. $150.00 Less Power Supply

"IT'S **D. & H.** *FOR DEPENDABLE PARTS SERVICE"*

D. & H. DISTRIBUTING CO., INC.

311 S. Cameron Street Harrisburg, Penna. — RADIO PARTS DIVISION — 31 East Lee Street Baltimore 2, Md.



WITH THIS COMPLETE RADIO KIT

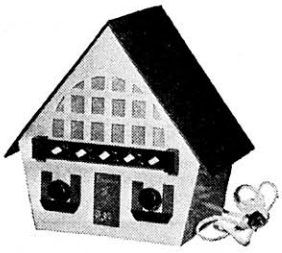
Direct From Manufacturer

PLUS 2 HOURS OF YOUR TIME

you can complete the assembly of an

EMPRESS RADIO

AT JUST HALF THE RETAIL COST!



IT WORKS LIKE A CHARM!
IT LOOKS LIKE A DREAM!

A delightful new note in home decoration . . . the EMPRESS captivates young and old alike. A welcome addition to any room in the house. Life-like tone . . . dependable performance . . . hair-line selectivity.

HERE ARE THE SPECIFICATIONS:

- 5 quality, long-life tubes.
- Broadcast Band—545—1630 KC.
- 2 Band 545—1630 KC, 7-15 MC.
- Operates on AC or DC current.
- 5 inch Dynamic Speaker.
- Size 10½" high, 8½" wide, 6¼" deep.
- Cabinet (optional), as illustrated, finished in cream, red and brown trim.

AND PLEASE NOTE:

- ✔ Sub-assemblies wired at the factory.
- ✔ Intermediate frequency transformers are pre-tuned.
- ✔ Built-in loop antenna.
- ✔ ALL PARTS CARRY FULL 90 DAY GUARANTEE.

$5 WITH ORDER **BRINGS IT ALL TO YOU!**

Fill Out and Mail Coupon Today!

EMPIRE DESIGNING CORP.
165 West 46th St., N. Y. 20, N. Y.

Please send me your COMPLETE EMPRESS RADIO KIT.

Check items desired: ☐ 1 Band $13.50. ☐ 2 Bands $14.50. ☐ Cabinet $4.50.

I enclose ☐ Check; ☐ Money Order for $5.00 and agree to pay the balance of $..... to the postman.

Name .....

Street .....

City ..... State .....

broadly tuned to the frequency of the oscillations. The amount of radio frequency current flowing in the primary of the r.f. transformer is governed by the capacity of C_1 — C_2. Plate C_1 is fixed, while C_2 vibrates, causing a variable radio frequency current to flow in the circuit in exact proportion to the vibration. C_2 is fastened to a stylus that is traveling in a groove on the record and is vibrated by the sound waves cut in the record groove. Thus, the modulated r.f. current flowing in the primary of the r.f. transformer is transferred to the secondary and rectified by any of the conventional detector circuits, passed through the usual filter circuit and then on to the audio amplifier and loudspeaker.

Inasmuch as the frequency passing through C_1-C_2 is very high, these plates are mechanically very small. Consequently, the vibrating member is very light, usually being made of aluminum. As this vibrating member does not have to perform any appreciable mechanical work (such as moving an air column or working against a heavy spring tension, as in a magnetic type pickup) it is allowed to "float" in the record groove. As it has very little inertia, it can readily respond to all the delicate overtones as well as all the fundamental notes. There is only one frequency to contend with, that of the oscillator, and since the only function of the capacity type of pickup is to vary the amplitude of this frequency, no difficulty was encountered in designing a circuit that would respond to the variations.

When the modulated radio frequency current is rectified in the detector circuit and filtered, an electrical wave which exactly corresponds to the sound waves put on the record is transmitted to the audio amplifier for additional reinforcement.

Thus we have the transition from earliest acoustical systems to electrical recording techniques.

Sound on Disc

Present day records are the result of modulated grooves which have been

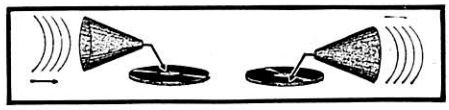


Fig. 8. Simplified process for recording and reproducing acoustical records.

cut on to a revolving wax plate or disc. From this disc, through intricate processing, are made the pressings familiar to all of you in the form of records purchased at your local record store. The basic media for making the necessary engravings or modulations on the disc are by means of a "cutter" which may be either magnetic, crystal or some of the new forms of dynamic instruments.

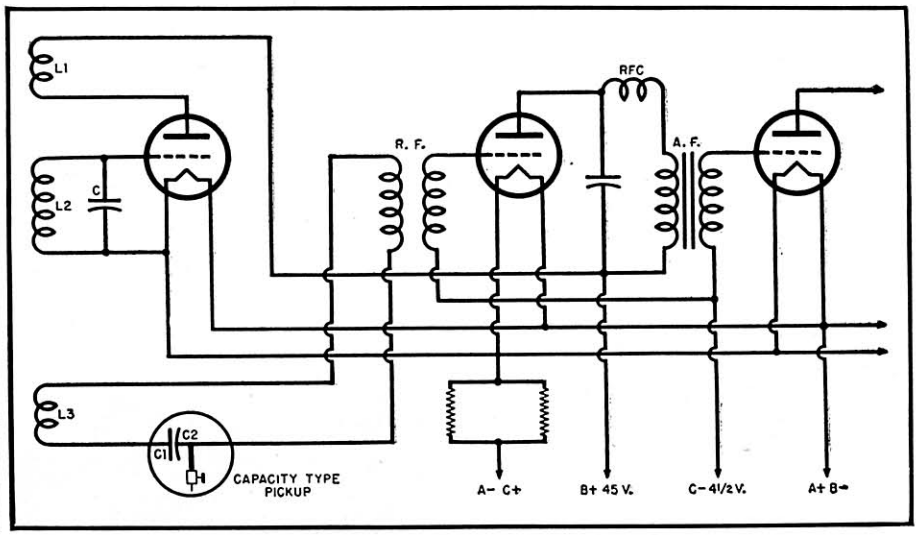
In order to understand what actually takes place at the cutting head, it is necessary to visualize the action of the stylus (the cutting needle) as it swings from side to side within the record groove. Its operation is similar to that of an engraving process done by hand. Instead of the hand guiding a cutting tool, a magnet or other source for actuating the cutting needle is used.

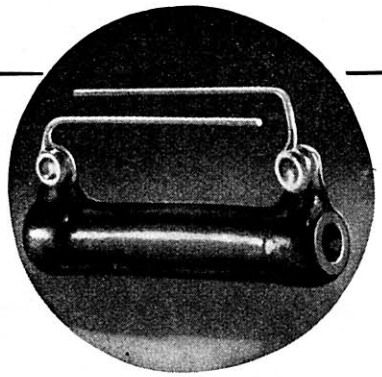
If a magnet is arranged as shown in Fig. 10, and a coil of wire placed in the position indicated, the magnetic field will be disturbed if a varying current (sound) is passed through the coil. If an iron armature is placed within the coil and a cutting stylus attached, this disturbance will actually move the armature back and forth within the field set up by the poles of the magnet.

This side-to-side motion does the engraving (modulating) on the walls of the groove. The high notes cause very small engravings, while the low bass notes actually cut deeper into the walls which are the sides of the groove. In other words, the action becomes more violent as the notes become lower. Bass notes, as a rule, have greater power or amplitude than high notes. This accounts for a greater swing of the cutting stylus from side to side.

From this explanation, we see that we must not give the low notes too

Fig. 9. How the capacity pickup of 1927 was connected to an audio amplifier.





5, 10 and 25 WATT

LECTROHM RESISTORS

available from stock

LECTROHM INCORPORATED

5131 West 25th Street, Cicero 50, Illinois

Division of the
National Lock Washer Company,
Newark, N. J.

Lectrohm wire wound, vitreous enameled, fixed resistors are proved to give the ultimate in dependable service life—rated resistance indefinitely—and now, are shipped right from stock. In Lectrohm Resistors it's quality foremost—wire is silver soldered to the solder lugs for perfect electrical bond always and entire unit (wire, lugs and core) are integrally embedded in vitreous enamel.

Ask for complete information.

"So may the outward shows be least themselves
The world is still deceived with ornament."

—William Shakespeare.

VERIFIED SPEAKERS

Do Not Come in Fancy Cartons.
Everything Goes Into Their
Efficient and Sturdy Construction.

That's why* RADIO SERVICEMEN *like them

★

WRIGHT, INC.

2231 University Ave. St. Paul 4, Minn.

RADIO-TELEVISION TECHNICIAN'S COURSE

- New Classes starting every 5 weeks.
- Either morning or afternoon classes. Full or Part time.
- Approved for veterans—Public Law No. 346 and No. 16.

Write for Free Bulletin on Courses

HOLLYWOOD SOUND INSTITUTE, Inc.

1040 N. Kenmore Ave., Los Angeles -:- MO 1-2345

RADIO SERVICEMEN

We specialize in standard brand, popular servicing items only. The absence of fancy inventories and catalogs makes our unusual prices possible. For example, compare:

Centralab Vol. Control, with switch, .5 meg.	$ .59
Solar Cond. 30-20 mfd., 150v.	.65
Mallory F.P. Cond. 10-10 mfd., 450v., 20 mfd. 25v.	.85
Meissner Hi. Gain I.F. Coils, 456 K.C.	.59
Resistor Kit, 100 Asstd. ½ to 1 watt, R.M.A.	1.95
Trebor P.M. Speakers, Alnico V, 4" and 5".	1.69
Nat'l Adv. 5 Tube Radio, AC-DC	18.95

Write Today for an Amazing Bargain Bulletin.

JOYCE RADIO CO., Box 2068, Hollywood 28, Cal.

TWA INVITES

Your List of Surplus Ground and Aircraft Radio and Electrical Material. Must Be New, in First Class Condition.

Address to:

TWA Purchasing, Room 325, Dept. A, 20 West 9th Street, Kansas City 6, Mo.

much power from the amplifier. To do so would cause the needle to cut right over to the adjacent grooves which would spoil the record. Fig. 10 illustrates how these notes appear on the record. The illustration is greatly enlarged for detail. Observe how the grooves take on the appearance of a winding stream as it might look to a pilot in an airplane from a high altitude. These grooves appear as straight lines when the needle is at rest. That is, the side-to-side motion stops and the groove is left unmodulated or free from sound.

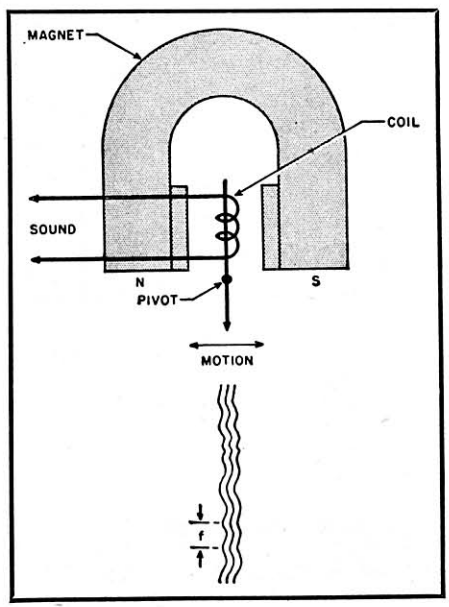
To complete the explanation, let us begin at the microphone and follow the sound waves all the way to the cutting stylus resting on the disc.

The sound waves are set up by the person speaking into the microphone. These waves actuate the mike in such a manner that these minute waves set up electrical variations in current in the microphone which follow the sound waves in cadence. These electrical current variations, although extremely small, pass through an audio amplifier where they are amplified to a value high enough to furnish audio power to the cutter and to move the cutting needle (stylus) which is resting on the revolving recording disc.

It stands to reason that if these current variations were weak, the cutting stylus would not receive enough power at the cutting head to drive the stylus from side to side in the groove. The result would be too much surface noise and not enough sound when the record was reproduced. On the other hand, if too much power is used, a poor record results, as will be explained in later articles.

Not only must the cutting stylus modulate the sound into the groove but, in modern practice, must also chisel out the groove itself. Thus, we have two basic actions: One, the creation or cutting of the grooves into the record material, which in the case of

Fig. 10. Simplified construction of the electro-magnetic cutter and its action.



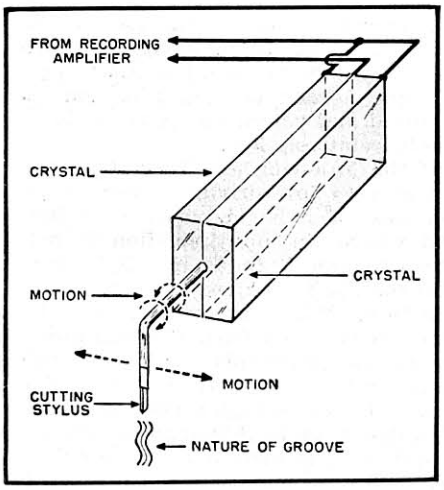


Fig. 11. How the crystal cutter modulates a groove when under electrical stress.

home recording, consists of a glass, paper, or steel base disc coated with lacquer, some form of acetate, etc. Second, the side-to-side vibrations of the stylus will be created from the sound entering the cutting head. Hence, modulation takes place at the same time the groove is being cut. The *groove* itself is that part of the material which is cut or chiseled out of the record. The *land* is that part of the disc remaining uncut between grooves. The material chiseled out by means of the cutting stylus is called the *chip* or *scrap*.

The Crystal Cutter

The piezoelectric crystal may be likened to a motor since it converts electricity into mechanical motion. There are two commonly used combinations of crystal elements known as the *bender* and *twister* types. The names *bender* and *twister* have been selected as they indicate the resulting motion of the crystal cutter when an electrical potential is applied. Both bender and twister elements, because of their multiple plate construction, are further classified as "bimorphs."

When audio power from the amplifier is applied to a crystal cutter, see Fig. 11, an electrical stress causes the lever connected to the cutting stylus to twist back and forth and to follow the sound waves that appear as electrical current variations.

Modulation is accomplished by the same chiseling action and the groove is modulated the same as with a magnetic cutter.

There is a distinct difference, however, in the behavior of crystal and magnetic cutters. Their complete characteristics and construction will be covered in later articles.

Thus, we have a brief explanation of capacitive, magnetic, and crystal cutters, all of which employ an engraving action on a revolving disc. Next month we will discuss systems for embossing on disc, sound on film, embossing on film, magnetic recording on film and the latest magnetic recording systems for tape, disc and wire.

(To be continued)

Bob Henry says:

MOST MODELS IN STOCK

for immediate delivery

Most models listed below are in stock . . . ready for immediate delivery:

Hallicrafters S38 complete	$ 47.50
Hallicrafters S40A	89.50
Hallicrafters SX42	275.00
Hammarlund HQ-129X less speaker	161.40
Hammarlund SP-400-X and speaker	342.00
National NC-2-40D (complete with speaker)	241.44
National HRO-5TA1 and HRO-5RA1	274.35
National NC-46	97.50
National 1-10A with tubes and coils	67.50
RME-45 complete	198.70
RME-84 complete	98.70
Pierson KP-81 complete	367.65
Panoramic panadapter complete	99.75
Temco 75GA transmitters	495.00
Meck 60T transmitters	150.00
Millen 90800 ECO	42.50
Millen 90800 exciter	37.50
Millen 90281 power supply	84.50
Millen 90902 scope	42.50

Gordon, Amphenol, other rotary beams. The new Hallicrafters and Collins receivers, transmitters, VFO, etc. as fast as available.

Prices subject to change.

● The delivery situation is much improved. I can make immediate delivery of most receivers and other apparatus. Take advantage of the extra service and selection you get by dealing with me, based on my reputation as the world's largest distributor of short wave receivers. Send me your order now. Send five dollars and I will ship at once C.O.D. Or order on my 6% terms. I finance the terms myself to give you better service and save you money. Trade-ins accepted. Tell me what you have to trade, and let's make a deal. Besides having all amateur receivers and transmitters, I also have a complete stock of all other amateur apparatus and parts, also test equipment, etc. I have real bargains in the really good war surplus. Write, phone, wire or visit either of my stores.

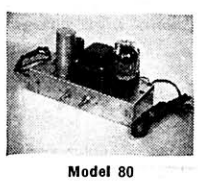
BOB HENRY, WØARA

HENRY RADIO STORES

Butler, Missouri, and

11240 W. Olympic Blvd., Los Angeles 25, Calif.

"WORLD'S LARGEST DISTRIBUTORS OF SHORT WAVE RECEIVERS"



Model 80

PHONO AMPLIFIER

●

IMMEDIATE DELIVERY

●

ORDER NOW!

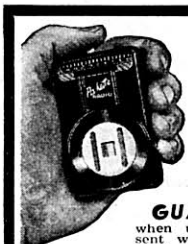
A SOLUTION TO YOUR AUDIO PROBLEMS

A.C. Only—4 watts output. Tone and volume control. Wired and tested. Complete with 6J5, 6V6 and 80 type tubes.

Unit Price **$10.50**

SOUND PRODUCTS CO.

80 MAIN STREET, WHITE PLAINS, N. Y.



AMAZING NEW Pocket or Purse Size RADIO!

Small as a Pack of Cigarettes! Weighs only a few ounces—Beautiful black chrome plastic case. Uses new war born crystal diode. Hi-Q-slide dial. No tubes—batteries or electric "plugs-ins." Usually receives local broadcasts without outside aerial wires.

GUARANTEED TO PLAY

when used according to instructions sent with each radio! You can use it at home, in offices, hotels, cabins, in bed, etc.—lots of fun—real entertainment!

SEND ONLY $1.00 (cash, money order, check) and pay postman $2.99 plus delivery fees on arrival or send $3.99 for postpaid delivery. Complete as shown **Ready to Play** with self-contained personal phone. For Gifts—children will love it—grown-uns too! An exceptional value—order yours and enjoy the many good radio programs coming! Don't be without your Pa-Kette Radio another day! (All foreign orders $5.00 U. S. cash.)

PA-KETTE ELECTRIC CO., Dept. RN-4, Kearney, Neb.

The RECORDING and REPRODUCTION of SOUND



Fig. 1. A 16 mm. Filmgraph recorder in operation with home movie projector.

By OLIVER READ
Editor, RADIO NEWS

Part 3. Introduction to basic methods for embossing sound on film and disc, magnetic recording on tape, disc, and wire, and optical film recording systems.

SO FAR we have dealt briefly with the lateral type of disc recording whereby a moving stylus actually cuts from and modulates a groove in a plastic or lacquer coated disc. Several improvements have been made in order to gain more time on a record of given size. Among these are the methods for embossing sound on disc at *constant groove speed.*

Constant groove speed, as the words imply, means that the linear speed of the recording track or groove, in inches per second, is fixed (see Fig. 2A). This remains constant regardless of record diameter. In the conventional phonograph, a fixed turntable speed is employed resulting in a very high speed in the outer circumference. Linear speed becomes progressively slower as the smaller inner circumferences are approached (Fig. 2B). The result is that varying amounts of distortion of the original sound are present. This is especially true at 33⅓ r.p.m. In order to compensate for the variable speed, several forms of equalization are required in order to boost the high notes as the speed becomes slower at the smaller diameters.

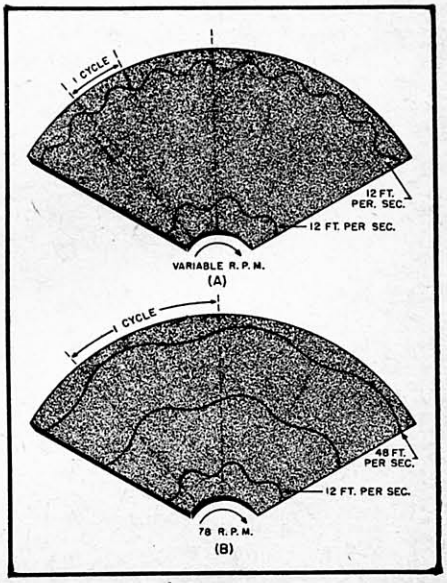
Constant groove speed techniques have been employed successfully in the design of highly efficient dictating machines such as the *Gray Audograph.* Vinylite records 10/1000 in. thick in sizes from 5⅝ to 8½ in. in diameter provide up to 31 minutes of dictation.

A roller drive at the stylus head provides constant recording speed. This speed is selected so that the maximum amount of dictation consistent with high intelligibility in sound reproduction can be embossed on the record (260 lines to the inch). This driving method does not require an extra mechanism to change rotational speed as the record center moves away from the stylus. The combination recording and reproducing head is illustrated in Fig. 3.

Three problems are encountered in playback stylus design; adjustment to vertical irregularities, adjustment to minute deviations from the Archimedes spiral that is theoretically traced during recording, and sensitive reproduction of the modulation pattern. The *Audograph* playback system comprises a stylus fixed on a flexible arm that is mounted on a heavy bar, a magnetic sleeve vertically set on the arm, a pivot shaft rubber-mounted in the sleeve, and a stationary coil surrounding the sleeve. Permanent magnets in the stylus head form a field about the coil. Lateral compliance is furnished by the heavy bar turning on the pivot; vertical compliance by the spring-loaded flexible arm.

Modulation reproduction can be followed from the schematic sketch. The groove force acts on the flexible arm through the stylus and weak torsion resistance, caused by the notches in the rear of the flexible arm, will permit the arm to tilt. This action tilts the sleeve mounted on the arm. As the ends of the sleeve rock forward, (one pole, then the other) lines of flux

Fig. 2. (A) Modulation by constant groove speed. (B) Constant hub speed produces variable groove speeds.



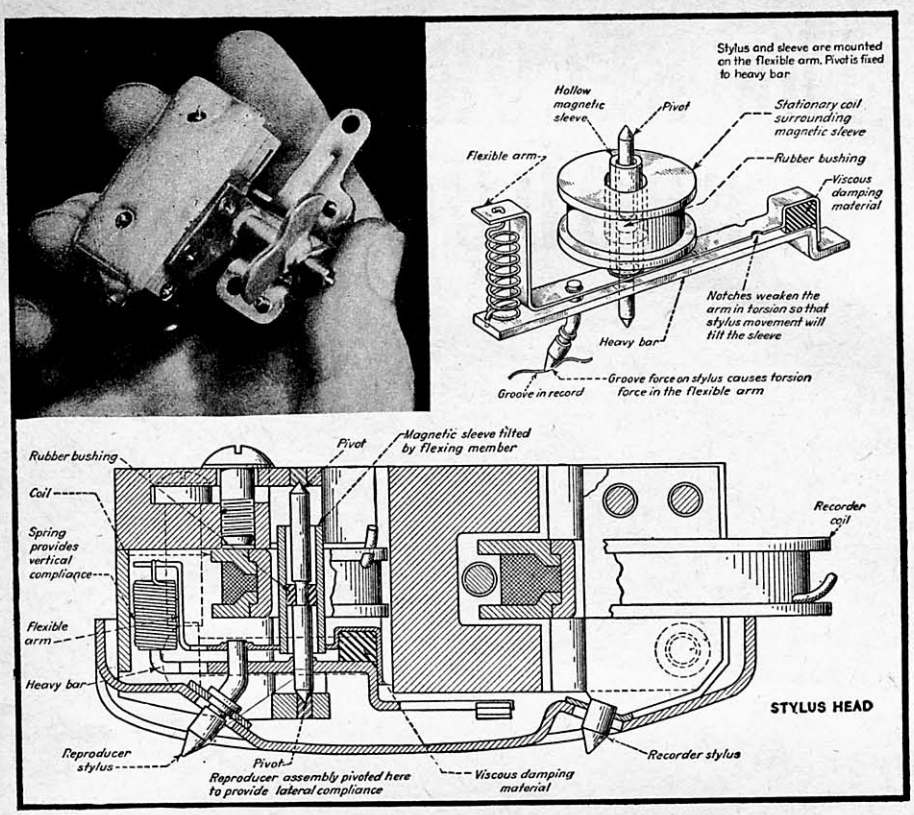


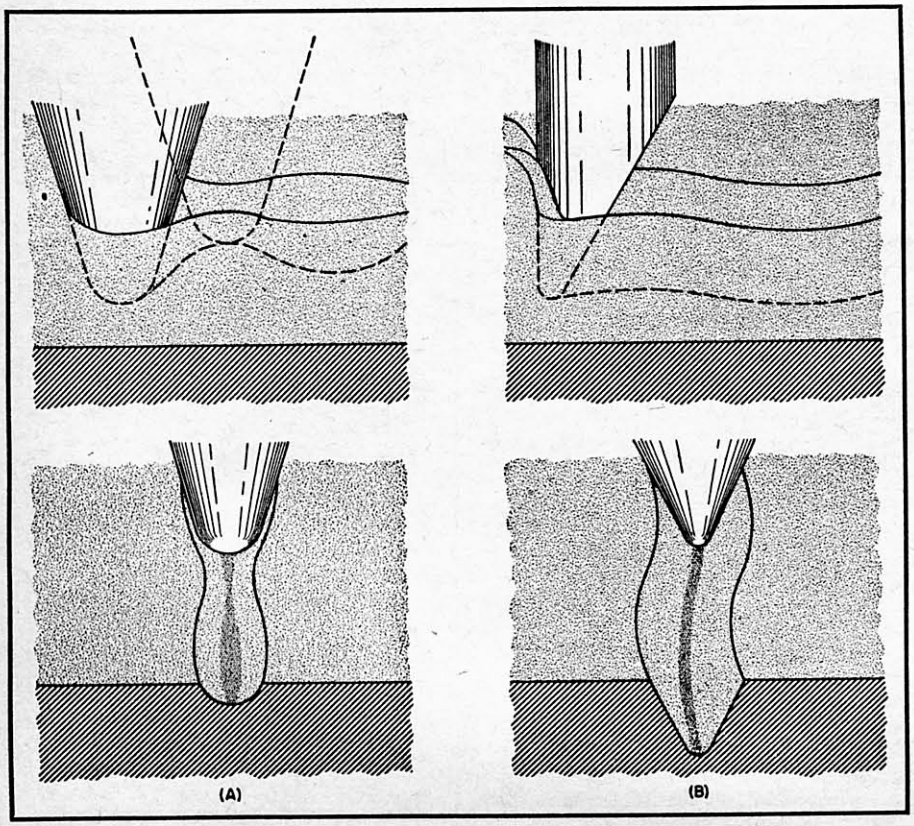
Fig. 3. Audograph record-playback head for embossing sound on Vinylite records.

flow through the magnetic sleeve, first in one direction and then in the other. This induces a voltage in the coil that electrically repeats the modulation pattern.

A belt reduction drive from the motor turns the driving roller. The idler roller, pressing the record against the driving roller, turns the record at a constant groove speed which is maintained throughout the recording. The angular velocity varies with the linear distance of the driving roller from the record axis. As the record turns the spindle, the carriage mechanism inside the case moves the record to the left.

A worm gear on the end of the spindle shaft engages a pinion on the end of the feed screw. Thus when the record turns, the feed screw is rotated. The feed screw, turning in engagement with the fixed worm pinion, is moved to the left, taking with it the carriage assembly that holds the spindle and record. In this manner, the record is slowly moved to the left while the driving roller rotates it beneath the recording stylus.[1]

(A) Embossing action of a dull stylus moving vertically. (B) Engraving action of a cutting stylus that is moving laterally.



Sound on Film

Original talking motion pictures were made possible by means of sound recorded on regular transcription discs and synchronized with the action as it appeared on the screen. This method became obsolete and was supplanted by the improved optical sound-on-film systems.

There are two general methods for recording sound on film. One is the *Movietone* method wherein the variations in sound are produced by *variable density* (variations in light through a sound track). This sound track has constant width along one edge of the film. See Fig. 4A. The other most commonly used method is the so-called *variable area* type. (*R.C.A. Photophone.*) Here the density remains fixed while the width of the sound track varies in accordance with the sound, as illustrated in Fig. 4B.

Variable density recording depends primarily upon the action of a "light valve." Basically, this valve consists of a loop of duraluminum ribbon, .003 in. thick and .006 in. wide, which is suspended in a very narrow slit between the two pole pieces of an electromagnet. Light from the exciter lamp is condensed and focused by means of a condenser lens system into a tiny path which shines through the slit in the light valve formed by the position of the duraluminum ribbons (Fig. 5). An objective lens system focuses and concentrates the tiny light beam onto the sensitized negative film which is traveling at a speed which is synchronized with the picture camera. The audio currents produce varying magnetic fields through the duraluminum ribbon loop. The varying magnetic fields cause the sides of the ribbon to repel each other. The amount of audio current flowing through the coils on the magnet governs the width of the slit, which in turn limits the amount of light that can pass through.

Reproduction from sound on film, employing the variable density technique, is shown in Fig. 6. The light from the exciter lamp, being focused into a very narrow beam, actually shines through the film to the photoelectric cell. The photocell, which is sensitive to variations of light, will pass minute variable electrical currents. These are then amplified by the audio system and fed through the

[1] Product Engineering, November 1946.

loudspeakers. The changes in the frequency of the sound are determined by the number of changes in film density per-inch-length of the sound track. The changes in the intensity of the sound are determined by the changes in the density or darkness of the lines on the sound track as the film passes the narrow beam of light. The light and dark lines on the sound track are continually interrupting the light going through the film. These interruptions vary the output currents of the photo-electric cell. Upon amplification, these variations or interruptions appear as sound waves and are heard through the speaker.

The fundamental setup for recording sound on film by means of the *variable area* method is shown in Fig. 7. Recording is accomplished by means of an oscillograph whose mirror is actuated by the variations in the intensity and frequency of the output voltage of the photocell. This, accordingly, throws a strong beam of variable light onto a moving film. These variations of light correspond to sound variations. They are recorded as a single heavy jagged line that looks very much like a series of high mountain peaks, as might be observed from a distance. Reproduction is similar to that of Fig. 6. Complete sound-on-film systems will be thoroughly discussed in later articles.

Embossing Sound on Film

One of the newer developments in sound-on-film is the technique employed to *emboss* sounds by means of a vertically driven stylus directly onto specially prepared film. See Fig. 8. One such machine, the *Filmgraph,* employs an endless loop of film which is placed in a magazine. The recording time depends upon the length of the loop used. Loops can be used for fifteen minutes', one hour's, two hours', five hours', and even up to eleven hours' recording. The loop moves forward continuously through the machine and no rewinding of the film is necessary. For example, if the recording is started on track No. 1, it automatically moves over to track No. 2 at the end of recording on track No. 1. This automatic movement continues until all tracks across the width of the film are indented or embossed. The track on which material is being recorded is indicated on a dial and this number changes as the stylus moves from one track to the other. Any track may be played back at any time by moving the stylus manually, by means of a control knob, to the desired number. Means are provided to start and stop the recording or playback instantly on a single word or syllable. A speed control is used on this type of machine for recording or playback.

The sound track is formed by indenting a groove into the film. The 16 mm. film is five-eighths of an inch wide and five-thousandths of an inch thick. A permanent type sapphire stylus of special design is used in the dual-purpose head for recording and playback.

The number of sound tracks that can be recorded on film depends on the physical width of the film. Sixteen or thirty-five millimeter film provides between forty and one hundred sound tracks. Sound may also be recorded on home movie film as shown in Fig. 1.

On the *Recordgraph* machine, sound is permanently embossed on thirty-five millimeter cellulose acetate film having a base material which is fire resistant and free of abrasives. No processing of the film is required before reproduction. Continuous recording with automatic trackover from groove to groove in the film is available. One hundred and fifteen tracks can be accommodated on one side of thirty-five millimeter film. Means are provided for the recording and also the locating of a particular track for playback as desired.

One of the earlier known methods of embossing is known as the *Western Electric* hill-and-dale recording technique. This is still used for many electrical transcriptions. Instead of a stylus moving laterally within a groove of a record, the stylus moves in a vertical plane and sound is actually cut and embossed by this motion.

Magnetic Recording on Film

The first talkies used the phonograph disc synchronized with the picture as mentioned previously. An optical sound track, however, proved itself better for most sound-on-film work. It is now used almost exclusively. *Magnetic* recording on film apparently has been neglected although it has some worthwhile advantages over the conventional optical systems.

Any system, no matter how successful in its application, has certain advantages and disadvantages compared to other methods. In optical recording systems we find that there is better resolution and better high frequency response at a given speed. There is no direct contact of the recording head with the film and neither is there any wear or clogging problem. The duplication of films recorded by the optical system may be accomplished easily by direct contact printing.

The disadvantages of the optical recording systems are briefly as follows: The films must be developed before the sound can be played back. They are relatively expensive and cannot be monitored immediately and as far as film technique is concerned, film must be handled in the dark and the processing requires highly skilled labor.

In the case of magnetic recording

(*Continued on page* 102)



(A)



(B)

Fig. 4. (A) Variable density sound track on 35 mm. movie film. (B) Variable area sound track as it appears on a single frame.

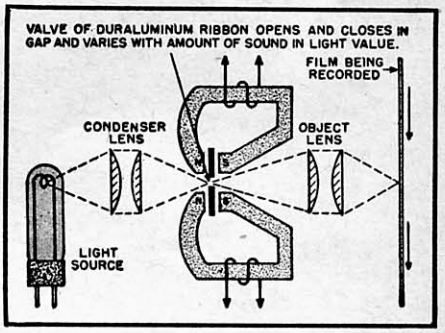
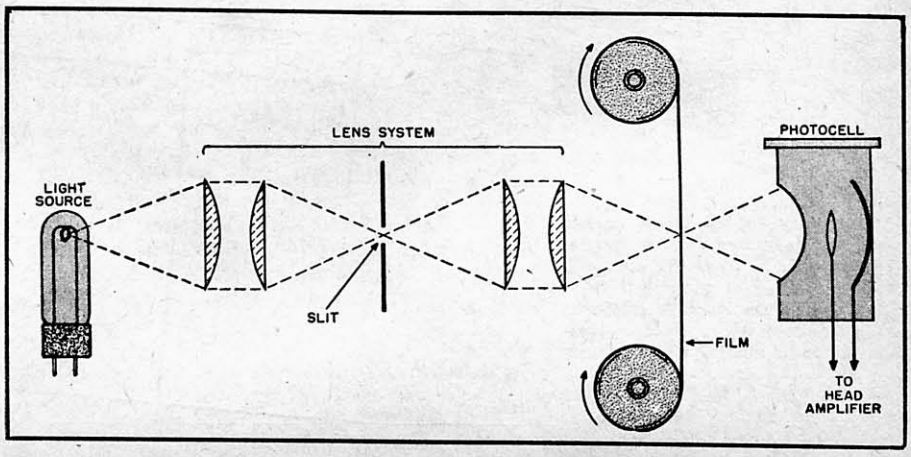


Fig. 5. The essential elements employed in variable density recording.

Fig. 6. Basic system for reproducing sound on film by optical methods.



SPECIAL! WRL MT-100 MULTITESTER
CAT. NO. 16-491
Less leads $19.45



Sturdy Steel Case—30-60 Degree Angle—Stand it up or Lay it Down. Ranges: DC Volts—0/5/50/250/500 V AC Volts—0/10/100/500/1000V, DC Mills — 0/10/100 Mills. Ohmmeter — Low Range 0-500 Ohms, High Range — 0-100,000 —1 Meg. 3" Meter. Size 5½x8x3¼. Here's a buy for every ham, experimenter, serviceman.



Our stocks of radio and electronic equipment are growing rapidly. We now have many items that have been scarce for years. Write for our latest Flyer or write us your needs. We are the only "personal service" radio parts mail order house in the country. For faster service order from WRL.—Leo W0GFQ.

ORDER YOUR RECEIVER FROM LEO, TODAY!

We carry all types and models, S-40, SX42, RME45, HQ 129X, and all National models in stock for immediate delivery. Collins receivers available soon. Buy on our easy payment plan —lowest terms in the country. Liberal trade-in allowance.



READ WHAT ANOTHER AMATEUR SAYS

About the WRL Globe Trotter Kit from J. M. Reagan, Del Rio, Texas—". . . and am proud to say it's the best little transmitter I have ever had the pleasure to operate. It's amazing the way it bucks QRM. I wouldn't take double the price I paid for it."

Many other actual field reports of amateurs using the Globe Trotter testify to its excellent performance. It's the hottest ham equipment on the market today. The WRL Globe Trotter is capable of 40 watts input on C.W. and 25 watts input on phone on all bands from 1500 KC through 28 Megacycles. Incorporates the Tritet Oscillator using a 40 meter Xtal; Heising choke modulation; three bands, all pretuned; 10, 20, and 80 meters; two power supplies, one for 807 final and modulator tubes, one for speech amplifier and oscillator stage.

IMMEDIATE DELIVERY

*All prices quoted are domestic. Write for export prices.

40 WATT INPUT. Cat. No. 70-300.. $69.95

Complete including all parts, chassis panel, streamlined cabinets, less tubes, coils and meter.

No. 70-312 Same as above, wired by our engineers $79.50
1 Set Coils, Meter, Tubes .....$15.15 Extra

World Radio LABORATORIES — EVERYTHING IN RADIO — INCORPORATED

Address Dept. RN-5, Council Bluffs, Iowa

Sound Recording

(*Continued from page 63*)

on film, we find the low cost of the magnetic system has much to offer in producing a picture more economically. The simplicity of handling this type of recording compares favorably with other forms of wire, tape and magnetic disc recording. Immediate monitoring is available with magnetic recording on film. No processing is necessary and the magnetic recording medium can be erased by demagnetizing. The sound strip may be used over and over until the quality and coordination of sound is perfect. No serious distortion with overmodulation is probable and any part of the sound track can be edited simply by erasing and dubbing in new sound.

There are two main disadvantages to magnetic recording on film: The recording head contacts the record surface which results in the possibility of wear, and the technical performance is not quite equal to the advanced optical methods now used by the large studios. However, it should be pointed out that the above facts are based on the present state of the art. As magnetic recording on film is perfected, it may even supplant the optical systems now commonly employed.

The method for recording and reproducing magnetic sound on film is illustrated in Fig. 9. A magnetic head assembly is employed and is mounted rigidly on an adjustable holder. In fact there are three heads each having an individual arm and a spring holding the head against the film while the latter rides against the brass drum. The upper head is used for erasing and removes sound from the magnetic track previous to the recording of new sound. The erase coil is fed with the conventional supersonic frequency of approximately 40 kc. Recording is accomplished at the center head. This contains a main audio winding plus an auxiliary high frequency coil. This

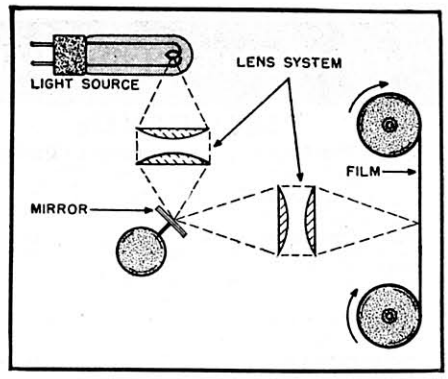


Fig. 7. The essential elements used for variable area optical recording.

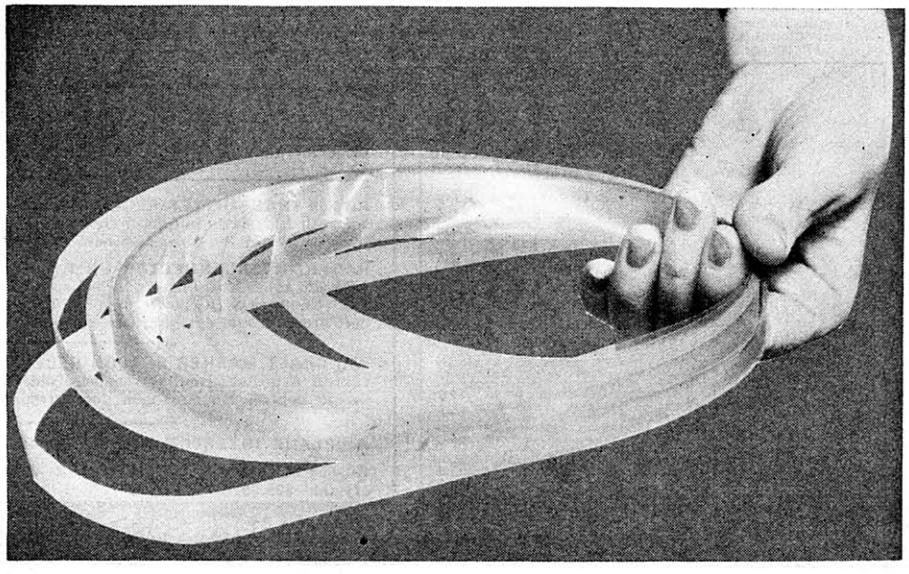
coil is connected in series with the erase coil to secure proper high frequency excitation. The third head is the monitor or playback head. This feeds directly through the amplifier and follows the picture by approximately fifty milliseconds.

Sections of various films are illustrated in Fig. 10. A magnetic material of approximately one-half mil in thickness is added to the emulsion on the film. The relative positions for the magnetized sound track are illustrated for various types of film, mainly the 8, 16, and 35 millimeter.

Magnetic recording on film bids fair to become extremely popular with the amateur projectionist. Home talking movies have become an economical reality and it is expected that with further improvements inexpensive projecting systems will be developed and will gain much popularity even with the novice.

There are other methods now employed for magnetic recording and these include magnetic recording on separate film. This is particularly suited for nonsynchronized work; for example, an eight millimeter film could be used with a full width sound track. This would be played on a second machine and would be synchronized with the other machine carrying the picture. Editing is very

Fig. 8. Endless loop of 35 mm. film used in the Filmgraph recorder.





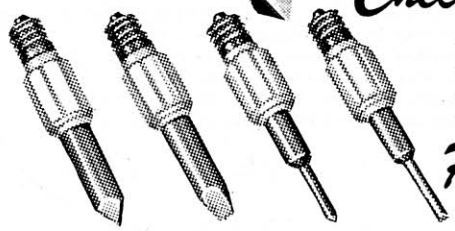
Light & Versatile
FOR BETTER SOLDERING

Patterned for durability and soldering ease, this nimble pencil iron is equally at home performing large heavy duty jobs or in the hard-to-reach spots requiring pin-point accuracy.

Check These Points!

- QUICK HEATING . . . 90 SECONDS
- LIGHTWEIGHT . . . . 3.6 OUNCES
- HANDY SIZE . . . . . 7 INCHES
- SAVES ELECTRICITY . . 20 WATTS

Perfect Balance!



No. 536 Pyramid Tip, made from Tellurium
No. 539 Chisel Tip, made from Tellurium
No. 538 Chisel Tip, made from Elkaloy A, Tip 1/8" dia.
No. 537 Pencil Tip, made from Elkaloy A, Tip 1/8" dia.

These 4 INTERCHANGEABLE tips give you a point for each particular job.

SEE YOUR NEAREST RADIO, HARDWARE OR HOBBY DEALER

UNGAR Electric Tools Co.
BOX 2255. TERMINAL ANNEX - LOS ANGELES 54, CALIF.

Presenting

The E.M.C. Volometer*
(trade name)

5 DC and 4 AC voltage ranges from 0 to 3000 V. Three current ranges. Four resistance ranges.

Resistances 1/20 ohm to 20 megohms. Low ohm scale is low drain back-up type. First ten divisions 1/20 ohm each.

AC volts 25 cycles to 1 megacycle. No external source of power required. Battery and rectifier replaceable without soldering iron. Matched-pair multiplier resistors accurate to 1%. 4½" meter.

For further information about this and other models, write us direct. For a conclusive demonstration, see your regular jobber.



MODEL 101 B (above) $20.95

Portable $24.95
Model 101 A $17.50
Same as above with 3" meters.
Portable $21.50

ELECTRONIC MEASUREMENTS CORP.
114 Liberty St. • New York 6, N. Y.

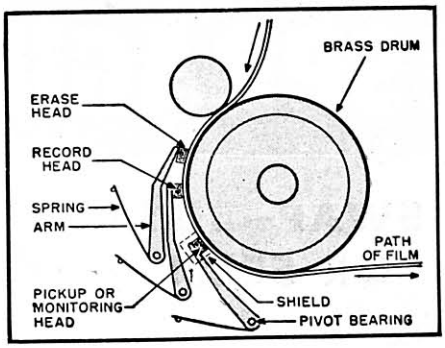


Fig. 9. Triple head assembly for recording and reproducing (magnetically) on film.

simple and the film may be cut and spliced in the usual way.

Magnetic Recording on Tape, Disc, and Wire

Fundamentally the recording on paper tape, paper disc, or wire is the same. The main difference lies in the mechanical means for driving the material to be magnetically recorded, in the means for playing back the sound, and in the employment of different techniques for recording the sound on the material.

Magnetic materials are drawn past a recording head. As the material passes the head, it becomes and remains magnetized. The amount of magnetism remaining in the material at each instant is governed by the signal impressed upon the recording head. In playing back, the magnetic material is drawn past a playback head. In many systems the recording and playback heads are the same, Fig. 11. The magnetization, which is variable, exists in the material and induces a corresponding voltage in the coil of the playback head. The functions of recording and playback are incorporated into a single record-playback head in most magnetic recorders.

It is a simple matter to erase any signal from any of the magnetic materials now employed. A strong field is set up within the erase head and this is impressed upon the material. This erases the old signal and makes the material ready to receive new signals. Basically, the tape, disc, and wire recorders consist of the magnetic material, the record-reproduce head and the erase head. In addition, of course, are the various types of driving systems used to draw the material through or over the head and the conventional amplifying and reproducing systems.

A supersonic oscillator, usually from approximately 30 to 40 kc., serves

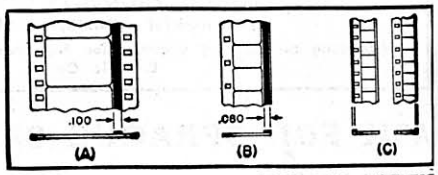
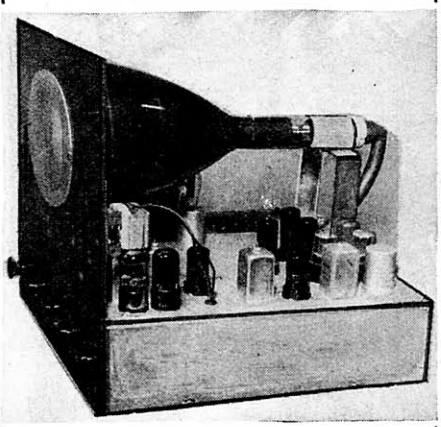


Fig. 10. Sections of 35, 16 and 8 mm. film showing the actual position of the magnetic sound tracks.

HIGHBRIDGE'S BEST BUY
NEW DYNAMIC
TELEVISION KIT



COMPLETE With Tubes—Parts—Cabinet **$159.50**

Exclusive Mail Distributors

Check These Outstanding Features:
- Three stages of video I.F. amplification—3.5 MC bandwidth.
- Receiver may be aligned easily without use of signal generator.
- Complete resistance and voltage analysis chart for easy trouble shooting supplied with each kit.
- IF transformers are slug tuned for high gain and maximum efficiency.
- Safety interlock switch supplied with each unit.
- Simplicity of operation—only 5 controls on front panel.
- Schematic diagrams are broken down into simple circuits for ease in wiring.
- Picture is very stable—does not jump or tear out even under unusual receiving conditions.
- Seventeen tubes including large picture tube.
- Picture tube is seven inches in diameter and gives a picture 26 square inches in size.
- All parts are unconditionally guaranteed to be electrically and mechanicaly perfect.

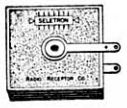
Set comes complete with all necessary information sheets, parts, drilled and punched chassis, beautifully finished front panel and modernistic cabinet. Hardware and other necessary items are also included. NOTHING ELSE TO BUY.

SONAR SOUND DETECTION UNIT
In Original Overseas Packing

Ideal for detecting underwater sounds within an area of 15 miles. Using a Rochelle salt xtal as the active unit the sound is transmitted up a 60 ft. cable. Completely enclosed in a solid rubber sheath. Originally used in harbor defense. Coupled with audio amplifier it has many valuable uses **$7.95**

SELECTRON SELENIUM RECTIFIERS

50 to 99.....85c
6 to 49.....90c
1 to 5.....99c



Quotations on larger quantities furnished upon request

USEFUL FOR:
- AC-DC Portables
- Intercom Power Supplies
- Console Radios
- Replaces 29 Types of Rect. Tubes

Gives Instant Reception—Requires No "Warm Up" Replaces Tube & Socket—Prolongs Life of Set Requires Less Space—Increases Sensitivity Made to Last the Life of the Set



NEW BATTERY BOOSTER

Powerful—Efficient Economical

A compact, lightweight, automatic, constant voltage battery charger which is especially designed to help car, truck or tractor owners keep 6 volt storage batteries fully charged. 4"x4"x5". Weights 4 lbs. packed. Operates on 105-120 v AC 60 Cy. DC 6 v 4-2 amp. Complete with 6 ft. AC cord with molded rubber plug and 6 ft. DC cord with alligator clips..... **$9.27**

Vision Research Laboratory design and construction of modern 5 or 7 inch television receiver Instruction Book and complete set of coils. Special **$6.95**

100 By-pass Condensers, 10 varieties, complete assortment. Special..... **$4.95**

New #631P1/SNA—Glass Strobotron tubes. Each..... **$3.25**

All Prices FOB New York City, N. Y.

Highbridge Radio—Television and Appliance Co.
343 Canal, CA 6-8661, New York 13

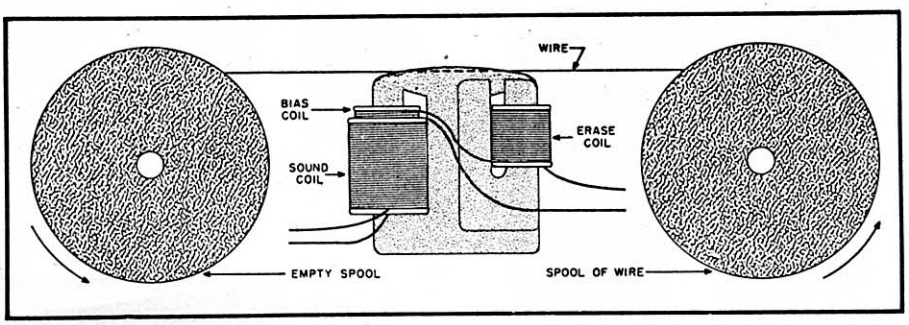


Fig. 11. Combined record-playback head assembly for wire.

the double purpose of providing high frequency for both the demagnetizing head and for the recording head. The material is first run through the erase head. Here it is demagnetized and made ready for the recording. The audio signal from the sound source appears at the recording head. The application of a supersonic signal to the recording head provides a bias. This is essential to overcome the non-linearity of the normal magnetization curve of the magnetic materials. Fundamentally these materials are the same. They differ only in their type of construction. These materials may be in the form of steel tape, wire, magnetized coating upon paper tape, or upon paper discs, or in fact the magnetized material may be coated or impregnated into various alloys.

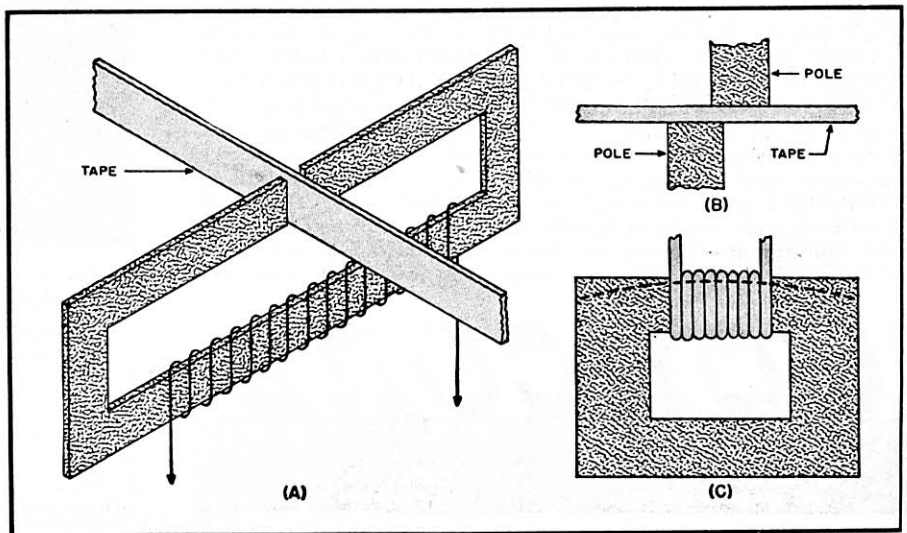
Insofar as quality of recording-reproduction is concerned, we find that speed is an all-important factor. The higher the speed, generally, the greater will be the fidelity. This will be completely explained in following articles.

The development of record-erase heads has gone on at a rapid pace. Beginning from cumbersome units often measuring four inches square, new tiny heads have been developed which are no larger than a regular two cent postage stamp. The magnetic field in these new units has been concentrated and condensed to a very small area. The slot, for example, in the case of a wire recorder head, often is not more than one-thousandth of an inch in width. The traveling wire passes through this slot and encounters the magnetic field set up by the head as in Fig. 11.

Three basic types of magnetic recording heads are illustrated in Fig. 12. In magnetic recording, frequency response, noise level, and signal amplitude are affected by the type of magnetic material used. At fixed speed and at lower frequencies, the retentivity, which is the measure of residual flux density, will determine the magnitude of the output voltage from the reproducing head. Generally speaking, the lower or bass notes must be suppressed when using magnetic recording. This too applies to the cutting of slow speed electrical transcriptions by means of lateral styli on discs.

Frequency response from the above systems, as mentioned, depends largely upon the speed of the magnetized material as it passes the head. A frequency response of between 60 and 8000 cycles per second can usually be obtained from most of the above machines. Recording time depends upon the material used and upon the physical size of the containers for the magnetized material. For example, the average wire recorder has enough stainless steel wire to operate for approximately 66 minutes at a speed of 2 feet per second. This type of recorder is being used to dictate this entire series of articles.

Fig. 12. Simplified diagrams of (A) record-reproduce head for transverse recording on tape, (B) offset, thick pole pieces which improve characteristics of head shown in (A), and (C) closed type wire record-reproduce head.



GOVERNMENT SURPLUS

We have on hand a large selection of Radio and Electronic Equipment purchased from the United States Government, and solicit your inquiry on practically any equipment or component parts used by the Army or Navy. Listed below are only a few of the many items we now have in stock.

Milliammeter—0-150 MA DC, Weston Model 506 2" $2.95
Steatite Socket Amphenol RSS4, 4 prong..... .12
Antenna Sections, 6 to unit, 18 ft. with insulated Mounting Bracket..... 6.50
without Mounting Bracket..... 3.00
Antenna Tuning Unit (used on Hallicrafters 400 Watt Army Transmitter). Has 15 amp RF meter Vacuum Cond., variable loading coils, etc..... 12.95
Condenser, MICA, .001 MFD—1000 V DC Aerovox type 1455—equipped with meter by-pass lugs..... .08
Condenser, 8 MFD 2000 V. Solar oil filled 3DB8-92..... 2.50
Condenser, Electrolytic, 40 x 40 x 40 x 40 250VWVDC Mallory FP can..... .75
Dynamotors, 12V DC, input to 1000 V DC output @ 350 MA. GE-BD-77 used with BC 191 transmitter..... 10.50
Fuse, FU-12A, ½ amp. 1000 V rating, ⅜" ferrule, 3" long..... .05
Headset, HS-33 NEW..... 2.25
Neon Bulbs, GE, ¼ W, 115 V, BAYONET base—base T 4 ½ bulb, type NE..... .15
Plastic transparent DISC, 6¼" dia x ⅛" thick, useful as scope tube protector..... .15
Plug, Jones (P-318AB) 18 contacts, male, chassis mount style..... .20
Plug, PL-540..... .15
Oil Capacitors, 1.0 MFD, 600 V Aerovox type 630..... .30
Resistor, 12,500 ohms, 50 W, ¾" Ferrule type, Ward Leonard..... .25
Resistor, 110 ohms, 50 W, ¾" Ferrule type, Ward Leonard..... .20
Resistor, 1 ohm 1" Ferrule type, 200 W, Ward Leonard..... .30
Selector Switches, Assortment of 10..... 2.00
Tuning Units for BC-375 and BC-191 contains Vernier tuning dials, variable condensers fixed cond., inductors, insulators, etc. $50.00 worth of parts..... 3.75
Scope, 5" tube 5CP1, 115V 60 cycle Primary. Used with SCR-545 as control unit. Has 15 tubes. Power supply self contained. Easily converted for servicing, etc..... 40.00
Choke, 12H @ 150 MA, 3000 Volt Test cased and impregnated..... 1.50
Choke, 30H @ 25 MA, shielded for use with pre-amp 1500 VRMS test..... .75
Choke, 9 H @ 300 MA, 1500 V DC cased and impregnated, 6½ x 6½ x 5½..... 1.50
Cathode Ray tubes, 12DP7, NEW, electromagnetic deflection. Long persistance screen.... 12.00
Relay, overload 12 amps cont. Allen Bradley No. 810, adjustable from 6.3 to 18.1 amps complete w/dash pot oil..... 3.95
Spark plug suppressors—6 for..... .35
Test Clip, Frankel w/point for making electrical connection, without removing insulation..... .05
Message Holder, excellent for station logs, regular letter size 8½" x 11" with extra clip for holding spare sheets, also protective cover. Reg. Signal Corps Type..... 1.25
Jeweled lamp assembly, 1" diameter. Panel mount Candelabra screw base socket. Red jewel..... .35

SPECIAL $25.00 OFFER

On a deposit of $5.00 we will ship you C.O.D. Freight Collect a large quantity of Government Surplus Radio Items subject to your inspection and approval. If, after inspecting you are not more than satisfied, return to us Freight Collect and all it will have cost you will be freight charges one way. You should be able to dispose of a few of the items that you may not need for the entire cost. This is the cheapest way we can sell you War Surplus Radio Material. Our warehouses are filled with thousands of choice Government Surplus Radio Items. Lots of them we do not have in sufficient quantity to advertise nationally and the cost of inventorying, itemizing, corresponding, etc., would only increase their cost, therefore we make this offer. If you wish to mention a few items you desire we will endeavor to include them in this assortment.

Above Prices F.O.B. Baltimore

Minimum Order $2.00

The ABELL DISTRIBUTING CO.
5 E. Biddle Street, Baltimore 2, Md.

Send for Our Flyer—
Name Items Interested In

Some of the paper tape machines run three or four hours. They employ regular 8 or 16 millimeter reels such as are used in movie projectors. They require more physical area for their mounting and are therefore a bit more cumbersome than the more compact disc or wire types.

We have touched but briefly on various methods for recording sound on disc, tape, wire, film, etc. Later articles will include the complete recording-playback systems for all of the above methods. Complete analysis will be given to each. There are so many means for recording and reproducing sound that we must first understand the functions of various component parts if we are to get maximum results from the systems.

Our next article will cover driving systems (cutters, embossers, etc.), their construction and characteristics.

(To be continued)

Mobile Radiotelephone

(Continued from page 47)

there is high local noise. Because of the large ratio of mobile units to fixed units, the over-all cost of service to the public is reduced by having the mobile units as small and simple as possible.

In determining the locations of the fixed land stations, field surveys are undertaken to determine propagation characteristics of the area. This is usually done by a combination of computation of field intensity over various paths and the making of actual field surveys.

Usually the land transmitter should be located at the highest available site in the vicinity of the area to be covered because of the line-of-sight propagation characteristics of very high frequencies. In general, the most suitable location for the land transmitting antenna will be on or above the roof of a centrally located building commanding a relatively unobstructed view in all directions of desired coverage. In some cities, hills may afford favorable sites; in others, a telephone central office or a midtown office building may be desirable to afford a high signal intensity where radio frequency noise is the highest. Here multiple-path transmission results from reflection and diffraction effects, causing signal field intensity to vary over a wide range within short distances. If the general level of signal intensity is relatively high, these variations are not very disturbing.

"Shadows," within which the signal intensity is considerably attenuated, may be cast by high buildings in the service area, and this effect is particularly marked on the far side of buildings near the transmitting antenna. In nearby "shadows," the high signal fields near the transmitter serve to offset the high attenuation enough to make the signal satisfactory, and the "shadow" area of high buildings a mile or more away from the transmitting antenna will be smaller and tend to fill in as distance beyond the interfering building increases. Increasing the height of the transmitting antenna often reduces this "shadow" effect.

In the case of land station receiving sites, the foregoing also applies. Another important problem is local radio frequency noise. The principal sources of noise at frequencies used in this service are man-made, such as electrical machinery, diathermy apparatus, etc. Thus locations should be selected where such interference is at a minimum.

The control terminal is usually located in a telephone building where a toll switchboard and toll power supplies are available.

The coverage of an area in a given direction is considered sufficient if the average signal-to-noise ratio is approximately 17 db. This ratio is determined from two measurements. The measurement of the magnitude of the signal is made with the transmitter fully modulated with a 1000-c.p.s. tone; the noise measurement is made with the transmitter on, but not modulated. The difference in signal and noise measurements in db. is the signal-to-noise ratio. These measurements may be made with the *Western Electric* 2B Noise Measuring Set.

Coverage measurements must take into account radiated power, distance from transmitting antenna, effective height of both transmitting antenna and receiving antenna, local noise, type of intervening terrain, and objects in the optical line of sight between the transmitting antenna and receiving antenna. Profiles of the terrain, drawn to take into account the curvature of the earth, are used in computations of coverage.

In the selection of land receiver sites, all of the above mentioned problems apply. The receivers, and particularly their antennas, should be located well away from noise-generating devices. In some cases it may even be desirable to locate one of the land receivers at or near the land transmitter. In the absence of actual measurements, the noise conditions may be estimated by grouping into four classes:

A. Very low noise — outlying residential area, light traffic; *B. Moderate noise*—residential area, moderate traffic; *C. High noise*—residential area or business district, heavy traffic; and *D. Very high noise* — business or industrial area, heavy traffic.

Measurements have indicated the radiated power necessary for sufficient signal-to-noise ratio at various distances under varying noise conditions and with various effective antenna heights. For example; with an antenna height above the effective ground plane of approximately 200 feet, range to be expected with 100 watts of radiated power at a frequency of 160 mc. over smooth earth under varying noise conditions is: *A.* Very low noise, approximately 30 miles; *B.* Moderate noise, approximately 25 miles; *C.* High noise, approximately 17

(Continued on page 113)

The RECORDING and REPRODUCTION of SOUND

By
OLIVER READ
Editor, RADIO NEWS

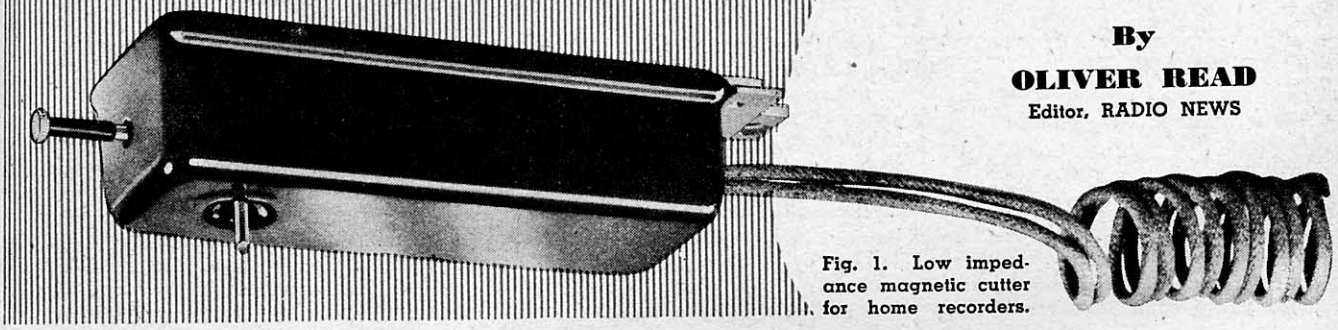


Fig. 1. Low impedance magnetic cutter for home recorders.

Part 4. A discussion of two representative magnetic cutters, one designed for home recording and the other for high-fidelity broadcast transcribing.

THERE are two widely used types of cutters for the engraving of sound on instantaneous discs, the magnetic and crystal.

The capabilities of each as regards frequency range, sensitivity and other refinements depends largely upon the type of construction and, equally important, upon the finished workmanship of the particular unit. There are expensive professional magnetic cutters for professional use as well as the inexpensive units designed primarily for home recording. It is an established fact, however, that many inexpensive magnetic and crystal cutters are quite capable of high fidelity cutting provided that the associated equipment is carefully designed and that particular attention is given to the mechanical construction, mounting, and circuits employed in using this cutter.

Construction varies with different makes and models but, like a motor car, accomplish similar results. Space does not permit a discussion of each of many excellent cutters, hence our discussion will be limited to representative types for home and professional applications.

Function

Most magnetic cutters are high-quality, wide-range recording units designed especially for instantaneous recording on nitrate, acetate and similar blanks. Ruggedness, stability, and high sensitivity make these units ideally suited for use with *home recording* equipment.

Magnetic cutters are low impedance devices and, as such, can be connected to the voice-coil side of the output transformer. The fact that switching is performed on the low-voltage side of the output transformer simplifies circuit design and makes possible considerable economy in equipment costs.

Structure

The *Shure Model 96* (Fig. 1) transducer has a balanced-armature, non-pivotal moving system which does not depend for its alignment or centering upon damping material. The high-permeability elastic armature has a stiff supporting and centering member, rigidly clamped to the frame, which maintains the whole moving system in exact alignment with the pole pieces, (Fig. 2.) This permits the use of a highly stable damping material solely as a dissipative medium instead of using it also to perform a centering function.[1]

[1] Shure Brothers, "Application Notes, Magnetic Recording Head," November 12, 1940.

The elastic armature and compliant supporting member, damping material, and needle chuck, constitute a mechanical wave network which provides unusually high sensitivity and smoothness of frequency response.

Magnetic cutters are exceptionally rugged and stable, and will give long and satisfactory service under all climatic conditions. Their cutting level and response characteristics are independent of temperature over a wide temperature range.

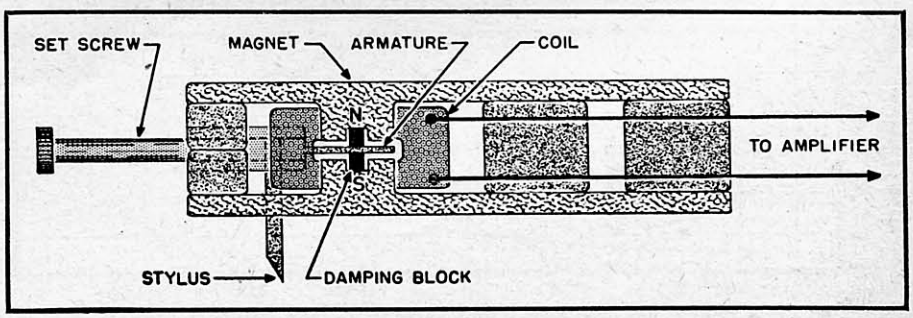
The rigidly clamped armature support will maintain its alignment indefinitely in both the rotation and axial modes, which was not the case with earlier mechanisms whose alignment depended on rubber bearings and damping blocks.

Electrical overloads will not readily damage the cutter or alter its characteristics.

Mounting

The magnetic cutter should be mounted in the recording arm or feed carriage so as to have complete vertical freedom, but no horizontal motion relative to the arm. Experience has shown that there are advantages in pivoting the cutter as close to the surface of the record as possible. The mounting, or arm, should preferably

Fig. 2. Details of assembly and structure of Shure Model 96 magnetic cutter.



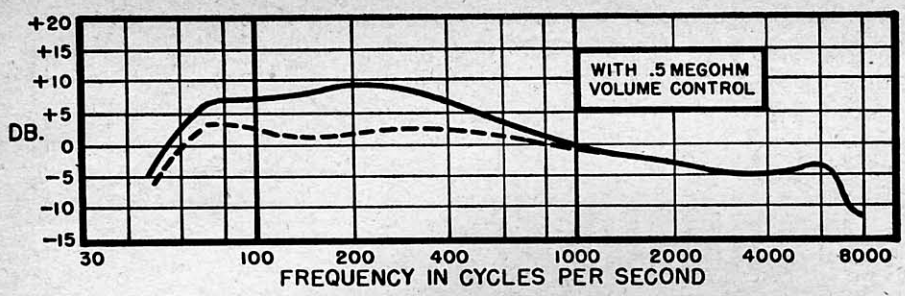


Fig. 3. Solid curve shows response of conventional crystal pickup when used without correcting filter. Dotted line shows response when filter of Fig. 4 is used.

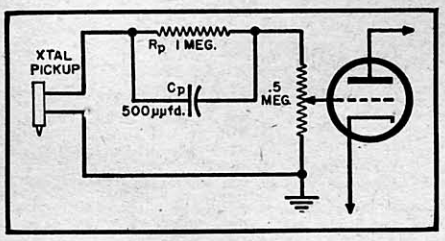


Fig. 4. Simple filter network that is often used for bass attenuation.

have means for adjusting the cutter pressure and the cutter angle. Under ordinary circumstances, the cutter will perform most satisfactorily if held parallel to the surface of the record; however, slight adjustments may be desirable with a given recording material or a given stylus. The pressure at the stylus point should be independent of the up-and-down motion of the cutter to insure groove uniformity on recording blanks which may be slightly warped.

Motorboard Vibration

It is particularly important in recording to reduce *rumble* and *feedback* to a minimum, inasmuch as records are often produced with insufficient volume thereby emphasizing background noises. Vibrations of the recording arm relative to the turntable will be recorded on the record and will appear during playback. The intermodulation of these vibrations with the recorded speech or music may have an undesirable effect on the quality of the record. The *motorboard* assembly should, therefore, be free of any appreciable vibration.

In many instances, a motorboard will be less subject to vibrations if it is tightly clamped to the recording cabinet. Elastic mounting of the motorboard (on springs or by similar means) may, under certain conditions, emphasize motorboard vibration and stylus chatter.

Then again, motorboard vibration may reside in an unbalanced driving motor, in idler wheels, or in turntable rims which in some cases are not perfectly round.

Severe motorboard vibration can sometimes be completely corrected only by elimination of the above causes.

Cabinet Vibration

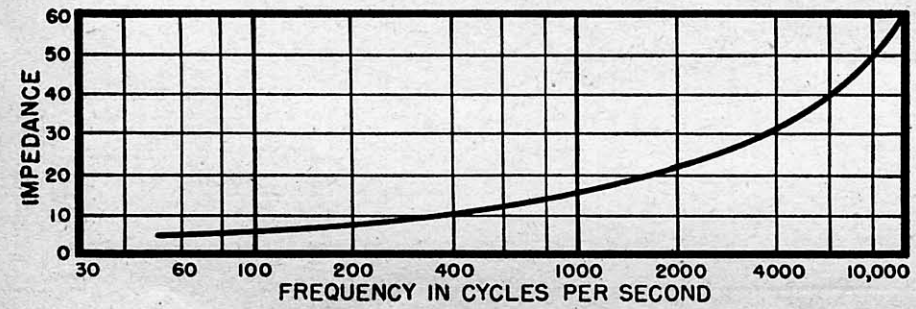
Since no cabinet is perfectly rigid, the speaker vibrations will carry through to the motorboard. Two separate effects may result from this vibration:

1. During recording, sound originating at the monitoring loudspeaker may cause vibration of the motorboard, thus changing the quality of the recorded signal.

2. During playback, cabinet vibration may be responsible for mechanical feedback between the playback pickup and the loudspeaker.

Both effects will be small in cabinets which are solidly constructed. In some instances, extensive experimental work may be required to eliminate the effects of cabinet vibration. Usually it is advisable to mount the loudspeaker elastically. In severe cases of mechanical feedback the motorboard may also be mounted on elastic pads, although this should be done with care to avoid the possibility of motorboard vibration and rumble. Often, an excessive low-frequency response of the playback pickup causes feedback and emphasizes motorboard rumble. Conventional crystal pickups have a rise at low frequencies (Fig. 3) when played on a standard test record (such as the *Audiotone* No. 78-1), and hence in a great majority of cases it is desirable to use these pickups with a simple correcting network, Fig. 4.

Fig. 5. Curve shows actual relationship between cutter impedance and frequency.



Recording Styli and Cutting Pressure

Styli made of steel, styli tipped with special alloys, or sapphire-tipped styli, may be used with the magnetic cutter. The life of the stylus depends upon the cutting properties of the record material. Because they are fragile and relatively expensive, sapphire-tipped styli are recommended only for the highest quality professional work, and generally are not used in the home. On nitrate or acetate blanks, a good quality steel stylus will usually retain satisfactory cutting qualities for about one-half hour of recording time. The so-called "short" styli having an over-all length of 5/8" and a diameter of .060" to .070" are recommended. The stylus should be fastened in the needle hole of the cutter with the flattened part of the shank toward the stylus screw. In the cutter being discussed the needle hole is properly designed to permit secure fastening of the stylus without the necessity of applying excessive torque to the stylus screw.

The correct stylus pressure must be determined by experiment, for it depends on the type and sharpness of the stylus, the method of pivoting the cutter, and upon the type, age, and temperature of the record blank.

The stylus pressure should be adjusted so that the width of the groove is .005 to .006 inches. This may be checked easily by observing the cut through an eyepiece having a magnifying power of approximately 10. The width of the unmodulated groove (in home recordings) should be approximately the same as the width of the "land" (or space between grooves) when viewed by diffused lighting. After the groove width has been properly adjusted, the required stylus pressure may be measured by means of a spring scale.

The following figures indicate the range of pressures which have been encountered on relatively inexpensive record blanks at a temperature of 75° F.

TYPE OF RECORD	STYLUS PRESSURE
1. Paper-Base Coated Record, Manufacturer A (hardest of the three)...	1½ oz.
2. Metal-Base Coated Record, Manufacturer B (medium hardness)...	1 oz.
3. Paper-Base Coated Record, Manufacturer C (softest of the three)...	7/8 oz.

The correct width and depth of the groove is of considerable importance. A cut which is too shallow may cause the playback pickup to leave the groove during loud passages. A cut which is too deep may cause adjacent grooves to run into each other causing "overcutting" and "echoes," and may increase the difficulty of thread clearance.

Recording Level

Experience has shown that for most satisfactory results the groove modulation in instantaneous recording blanks should be somewhat less than that in commercial pressings. The soft coating of instantaneous recording blanks usually cannot withstand severe overmodulation without producing distortion and echoes. This is

particularly true with equipment recording at 110 grooves per inch. Good home recordings are obtained with a level approximately 4 to 8 db. lower than that of commercial pressings. To obtain a groove modulation having a level approximately 6 db. below commercial recordings (as exemplified by the *Audiotone* No. 78-1 test record), it is recommended that the voltage peaks measured with a sensitive rectifier-type meter connected across the cutter should be approximately $\sqrt{Z/5}$ volts where Z is the 400 cycle impedance of the cutter.

The following table lists the suggested voltage peaks across cutters (such as the Model 96) of various impedances, as measured by a medium-speed volume indicator connected across the cutter terminals:

DC RESISTANCE	400 CYCLE IMPEDANCE	VOLTAGE PEAKS
½ ohm	1.2 ohms	½ volt
1 ohm	2.5 ohms	.7 volt
2 ohms	5.0 ohms	1 volt
3 ohms	7.5 ohms	1.2 volts
4 ohms	10.0 ohms	1.4 volts
5 ohms	12.0 ohms	1.6 volts
6 ohms	15.0 ohms	1.7 volts
8 ohms	20.0 ohms	2 volts
12 ohms	30.0 ohms	2¼ volts

The values in this table may serve as a rough guide for settings of recording level indicators (described in detail in later articles) or in conjunction with the table in Fig. 5, Part 1.

Impedance Matching

Considerable experience in the application of magnetic cutters to commercial home recording equipment has emphasized the fact that the cutter impedance must be correctly related to the output impedance of the audio system if good quality reproduction is to be obtained. This is particularly true with pentode type output tubes. The correct impedance relationship can be obtained by revision of the output transformer secondary winding, or by selection of a cutter of required impedance. Cutters of the following impedance values are generally available:

DC RESISTANCE	400 CYCLE IMPEDANCE
½ ohm	1.2 ohms
1 ohm	2.5 ohms
2 ohms	5.0 ohms
3 ohms	7.5 ohms
4 ohms	10.0 ohms
5 ohms	12.5 ohms
6 ohms	15.0 ohms
8 ohms	20.0 ohms
12 ohms	30.0 ohms

The total impedance reflected into the output stage by the cutter and the associated circuit components (such as the monitoring loudspeaker, level indicator and dummy loads, if any) should be equal to the optimum load value recommended by the tube manufacturer. This impedance may be calculated approximately with the aid of the values given in the paragraphs below; however, it is suggested that an impedance bridge be used for final determination of the total load imposed upon the output stage. Inasmuch as the load impedance will, to a certain extent, vary with frequency, it is suggested that matching be done at 400 cycles per second, which is the frequency of probable power peaks of speech and music.

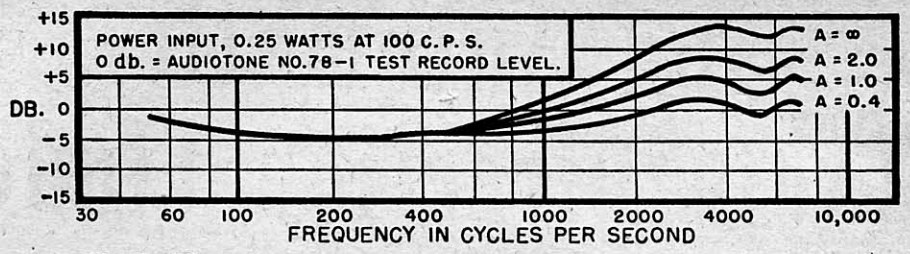


Fig. 6. Effect of resistance across cutter in pentode circuits. The ratio of the parallel resistance to the cutter impedance is represented by A.

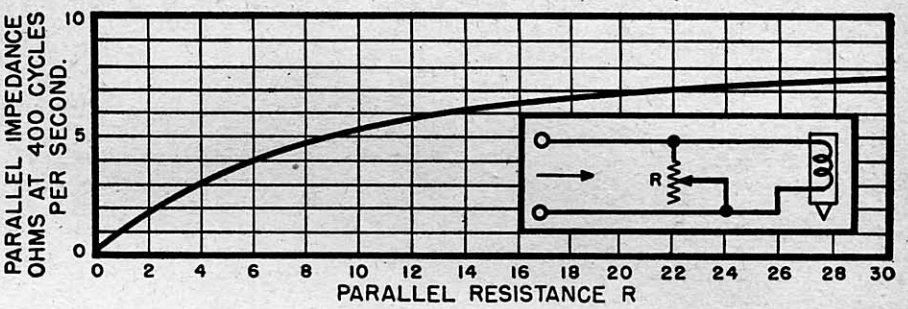


Fig. 7. Chart used to determine parallel 400 cycle impedance.

Cutter Impedance

The impedance of the cutter is a function of frequency because of the inductance and iron losses in the magnetic circuit. The impedance increases from the nominal d.c. value of the cutter resistance in accordance with Fig. 5. Thus, a cutter having a d.c. resistance of 4 ohms will have an impedance of approximately 10 ohms at 400 cycles per second, 15 ohms at 1000 cycles per second, 43 ohms at 7000 cycles per second and 60 ohms at 10,000 cycles per second.

Total Impedance of Cutter and Auxiliary Circuits

In connecting the cutter to pentode output tubes, optimum loading conditions combined with good recorded response may be obtained by connecting the cutter in parallel with a resistance having a value of ½ to 2 times the 400 cycle impedance of the cutter. The effect of the parallel resistance on recorded frequency response is illustrated in Fig. 6. After a suitable response curve has been determined, the 400 cycle impedance of the parallel combination of cutter and resistor may be found from Fig. 7, for a 9611-B4 (10 ohms at 400 c.p.s.) cutter; however, it may be used for cutters of different impedance by multiplying all values given on the curve by $Z/10$ where Z is the 400 cycle impedance of the given cutter.

For the purpose of approximate calculations in computing the series and parallel impedance of the load, it is permissible to treat the 400 cycle cutter impedance as if it were a d.c. resistance, inasmuch as the "*Q*" of the cutter is 0.8 at that frequency. For example, a 9611-B4 (4 ohms d.c., 10 ohms at 400 cycles) cutter is connected in parallel with a 15 ohm resistor. The total parallel impedance may be found from Fig. 7 to be equal to 6.3 ohms or it may be calculated approxi-

(*Continued on page* 122)

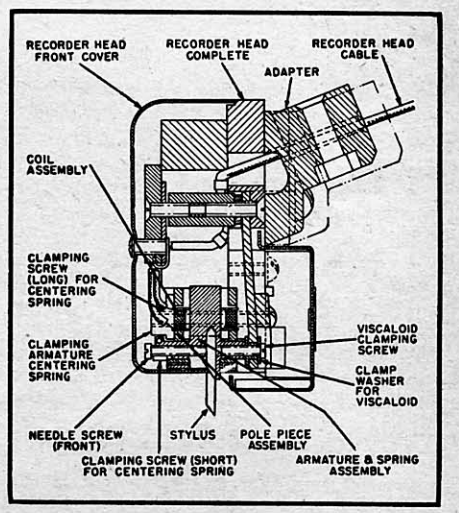
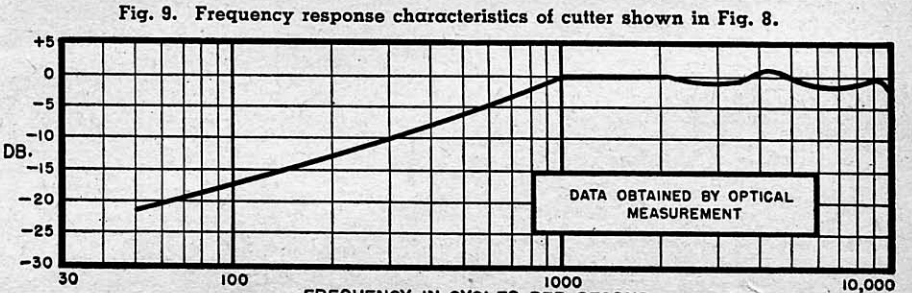


Fig. 8. Precision assembly of high quality magnetic cutter (RCA MI-4887).

Fig. 9. Frequency response characteristics of cutter shown in Fig. 8.



Now Available for
IMMEDIATE DELIVERY
Complete
TELEVISION COIL KIT

With these Coils, Construction of Your Television Set is Simplified

Instruction Manual for 20 Tube, 7 inch Picture Tube Set, included with each Kit.

Designed by Television Engineers these Coils are able to meet most exacting requirements. This Kit makes it possible

FOR THE HOME CONSTRUCTOR

to build a set of excellent quality able to receive six channels of Television Transmission with FM Sound

AT LOW COST

Look at these

SPECIFICATIONS

IF COILS

- **Bandwidth of 4.25 MC that can operate ANY size Picture Tube with Maximum resolution**
- **Permeability Tuned, All Coupling Coils and all Traps**
- **Shielded; "CAN" Mounted**
- **Adjacent Channel and Sound Traps**
- **Built-in Coupling and Filter networks**

***RF TUNER ASSEMBLY**

- **6 Channels, No. 1 to No. 6 inclusive**
- **Permeability Tuned, All Channels**
- **Maintains Gain and Bandwidth over all Tuning Ranges**
- **High Sensitivity**
- **Antenna Coil, RF Tuning Coils, Oscillator Tank Coil, all mounted on Switch Assembly Plate**

OUR $23.50 OFFER

INCLUDES THE FOLLOWING

1 Oscillator Tank Coil, 1 Antenna Coil, 6 RF Tuning Coils, all mounted on Switch Assembly Plate; 5 Video IF Coils, Shielded, Permeability Tuned; 1 Shielded Discriminator Coil; 3 Video Peaking Coils, and Instruction Manual containing Circuit Diagram for 20 Tube Seven Inch Picture Tube Set, together with detailed Assembly Instructions, and Parts list.

The design of these Coils makes it possible to obtain satisfactory operation within the ENTIRE service range of ANY Television Station.

If Our Instructions are Followed

SATISFACTION IS GUARANTEED

All Special Coils are in this Kit. Remaining parts are easily obtainable.

TERMS

Shipped Express Prepaid on receipt of check or Money Order. Or Express Collect on receipt of 25 per cent deposit with order, balance C.O.D.

**Patent Applied for.*

RAY-LECTRON CO.
"Television Kit Headquarters"
BELMAR, N. J.

wound an antenna coil for it and set it on top of the other coil for the antenna and counterpoise and had a condenser across the main inductance instead of direct coupled like it was at the start. Well, anyway, I just sat there looking—turned the darn thing on and just looked some more. After a while I reached over and unclipped the tank condenser—*it still oscillated!* What frequency? Son, you ask the darnedest things, how'd I know what frequency? Pretty soon I reached over again and moved the grid and plate taps a turn closer together—it still oscillated — another tap — and another, until, by gosh, son, I could hear the darn thing on the 40 meter band. Just sat there lookin' and thinkin' about that a few minutes—shucks I didn't think there was any use calling anyone, the antenna meter wasn't moving off the peg a darn bit, couldn't work anyone that way but well, I figured I might as well call just one CQ. Anyway I beat out a short CQ and started down the band kinda feeling like the guy with the net *should* get me before I did something really violent. Was about halfway down the band when—what was that? A guy calling 9DEX—just as sure as I was alive and it was a ONE! Yes sir son-a 1,—1BDR in fact, I'll never forget it—I kinda remember he was the guy that beat me out of first place in the national Sweepstakes contest quite few years after that too.

Well anyway son the gate was open, got three or four sixes some 1's, 2's, 3's, NAJ and a bunch of 8's etc. All with no antenna current at all and that big antenna tuned to 175 meters. I didn't know from shucks why but boy there was my log. I was sure sold, hook, line and sinker. But son that wasn't the best part of it—all during the evening I was hearing the harmonic of 9AEF and 9AFW (who had consolidated with a UV203) pounding away on 200 with the QRN beating them on the head something awful and them not hearing much of anything else. Well the next day I slipped AEF a list of my QSO's and you shoulda seen him turn green.

I guess after that I just went along through the usual stuff—new transmitter, new antenna, new receiver, new transmitter, new antenna, etc., etc. Got clear up to a fifty watter once, didn't work a dang bit better than my old 202's though. Went down to twenty about that time—we really had a good thing down there then, 14,000 to 15,000 kc. I think it was, 7000 to 8000 kc. on 40 too. The hams got a few dealt off the bottom of the deck along about 1929 they darn near lost 40 and 20 for sure—The ARRL put up a fight I guess but most of us thought someone sold us down the river. It ain't never been the same since—that really ended the good old days for sure.

Well son it's getting kinda late, I can't miss my sleep like I used to. Come around tomorrow and I'll give you a little code practice.

—30—

Sound Recording

(*Continued from page* 67)

mately as 10x15/ (10+15) = 6 ohms. The ratio A in this instance is 15/10 = 1.5. If this parallel combination is now connected in series with a 3 ohm monitoring loudspeaker voice coil, the total 400 cycle impedance of the load will be 6 + 3 = 9 ohms.

Again, if, for the purpose of monitoring, a 6 ohm speaker voice coil is connected in parallel with a 1 ohm resistor, and this parallel combination is connected in series with another parallel combination consisting of a cutter (10 ohms at 400 cycles) and a 10 ohm resistor, the total load impedance will be

$$\frac{1\times6}{1+6} + \frac{10\times10}{10+10} = 5.86 \text{ ohms.}$$

This series-parallel circuit then can be connected into the 6 ohm winding of the output transformer.

In general, level indicating devices consume a negligible amount of power. However, in the case of relatively insensitive indicators such as pilot lamps, the indicator impedance should be considered as part of the total load of the circuit.

Magnetic Cutters for Professional Applications

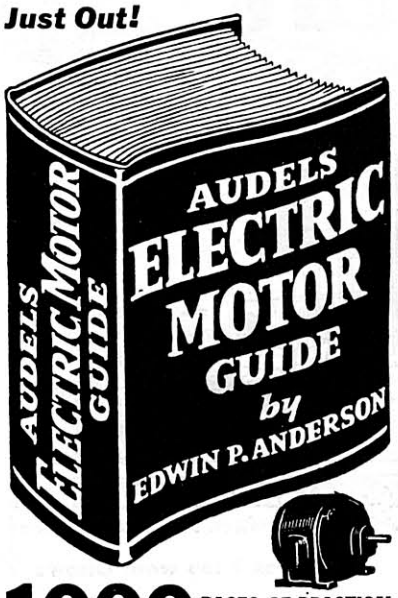
High fidelity recording heads, such as the *RCA* MI-4887, are high quality magnetic units precision built and accurately adjusted. They are primarily intended for use on composition coated discs, or can be used on wax, since they do not depend on the record material for damping. The unit illustrated is held within close frequency limits and does not depart from an ideal response curve more than two decibels between 50 and 10,000 cycles per second. Heads are matched for sensitivity within two decibels at 1000 cycles per second. In physical construction, it represents a bandpass mechanical network terminated in a dry mechanical resistance material. The armature is of the balance type and is centered by means of an adjustable tempered steel spring. The armature is supported on rugged knife-edge bearings. Pole pieces are made of nicaloi. (Fig. 8)

Recorders using these professional heads should be operated in a temperature controlled room for most uniform results. Frequency response and sensitivity are standard at 72 degrees F. and vary slightly with temperature. Between 65 degrees F. and 80 degrees F. the cutters will remain fairly close to normal characteristics, the variations not exceeding 3 db. from the response at 72 degrees F. Performance data at the time of manufacture is obtained by scientific optical means, thus excluding errors which might arise from commercial tolerances in cutting styli and disc materials.

A typical response frequency characteristic of the head is shown in

7 Days Free Examination

Just Out!



1000 PAGES OF PRACTICAL MOTOR INFORMATION

AUDELS ELECTRIC MOTOR GUIDE covering the construction, hook-ups, control, maintenance and trouble shooting of all types of motors including armature winding. Explains entire subject in every detail. 31 Chapters, 617 Illustrations & Diagrams.
A Handy Guide, Fully Indexed
for Electricians and all Electrical Workers.

$4 COMPLETE • PAY ONLY $1 A MONTH

Step up your own skill with the facts and figures of your trade. Audels Mechanics Guides contain Practical Inside Trade Information in a handy form. Fully Illustrated and Easy to Understand. Highly Endorsed. Check the book you want for 7 days Free Examination.
Send No Money. Nothing to pay postman.

—— CUT HERE ——

MAIL ORDER

AUDEL, Publishers, 49 W. 23 St., NEW YORK 10, N. Y.

Please send me postpaid for FREE EXAMINATION books marked (x) below. If I decide to keep them I agree to mail $1 in 7 Days on each book ordered and further mail $1 monthly on each book until I have paid price Otherwise, I will return them.

- ☐ ELECTRIC MOTOR GUIDE, 1000 Pages . . . $4.
- ☐ ELECTRICIANS EXAMINATIONS, 250 Pages . 1.
- ☐ WIRING DIAGRAMS, 210 Pages . . . . . 1.
- ☐ ELECTRICAL DICTIONARY, 9000 Terms . . 2.
- ☐ ELECTRICAL POWER CALCULATIONS, 425 Pgs. 2.
- ☐ ELECTRONIC DEVICES, 216 Pages . . . . . 2.
- ☐ RADIOMANS GUIDE, 914 Pages . . . . . 4.
- ☐ HANDY BOOK OF ELECTRICITY, 1340 Pages 4.
- ☐ ELECTRIC LIBRARY, 12 vol., 7000 Pgs., $1.50 vol.
- ☐ OIL BURNER GUIDE, 384 Pages . . . . . 1.
- ☐ REFRIGERATION & Air Conditioning, 1280 Pgs. 4.
- ☐ POWER PLANT ENGINEERS Guide, 1500 Pages. 4.
- ☐ PUMPS, Hydraulics & Air Compressors, 1658 Pgs. 4.
- ☐ AUTOMOBILE GUIDE, 1540 Pages . . . . . 4.
- ☐ DIESEL ENGINE MANUAL, 400 Pages . . . 2.
- ☐ WELDERS GUIDE, 400 Pages . . . . . 1.
- ☐ BLUE PRINT READING, 416 Pages . . . . . 2.
- ☐ SHEET METAL WORKERS Handy Book, 388 Pgs. 1.
- ☐ SHEET METAL PATTERN LAYOUTS, 1100 Pgs. 4.
- ☐ AIRCRAFT WORKER, 240 Pages . . . . . 1.
- ☐ MATHEMATICS & CALCULATIONS, 700 Pgs. . 2.
- ☐ MACHINISTS Handy Book, 1600 Pages . . . 4.
- ☐ MECHANICAL Dictionary, 968 Pages . . . . 4.
- ☐ MARINE ENGINEERS Handy Book, 1280 Pages 4.
- ☐ MECHANICAL DRAWING GUIDE, 160 Pages . 1.
- ☐ MECHANICAL DRAWING & DESIGN, 480 Pgs. 2.
- ☐ MILLWRIGHTS & Mechanics Guide, 1200 Pgs. 4.
- ☐ CARPENTERS & Builders Guides (4 vols.) . . 6.
- ☐ PLUMBERS & Steamfitters Guides (4 vols.) . 6.
- ☐ MASONS & Builders Guides (4 vols.) . . . . 6.
- ☐ MASTER PAINTER & DECORATOR, 320 Pgs. 2.
- ☐ GARDENERS & GROWERS GUIDES (4 vols.) 6.
- ☐ ENGINEERS and Mechanics Guides Nos. 1, 2, 3, 4, 5, 6, 7 and 8 complete . . . 12.
- ☐ Answers on Practical ENGINEERING . . . . 1.
- ☐ ENGINEERS & FIREMANS EXAMINATIONS . 1.

Name_____

Address_____

Occupation_____ RN

Employed by_____

Fig. 9 and is based upon measurement of the stylus tip motion for constant input. It does not include transfer or needle losses which occur in both recording and reproduction and which are rather severe at high frequencies (at low record surface speeds).

Distortion in records made with this head is extremely low. If distortion should be observed, it can usually be attributed to overmodulation which results in failure of the reproducer stylus to follow the groove. Such heads, when properly used, can consistently produce records equal in quality to the finest commercial transcriptions.

A compensator pack (Fig. 10) is provided to nullify the inductance of the head and present to the amplifier a nearly constant impedance. The recommended connections provide a resistance of 10 ohms in series with the cutting head. This resistance is bypassed with a 0.5 μfd. condenser. The only purpose in making the compensator adjustable is to permit obtaining identical sensitivity among heads when more than one is used. Critical operators may wish to compensate for manufacturing tolerances by slightly increasing the value of series resistance in the high sensitivity units and slightly reducing it on the low heads. This should be done in steps of not more than 2.5 ohms which is possible by series-parallel connections. See Fig. 10. In no case should the total resistance in series with the head be less than 7.5 ohms or the frequency response will be seriously affected. High frequency response can be altered by varying the value of the capacitor.

The proper depth of groove can be found by observing the width relative to the remaining wall. The wall should be approximately two-thirds of the groove width. Or, in other words, forty per-cent wall and sixty per-cent groove. Some operators prefer to measure the thread thickness with a micrometer having a ratchet for insuring uniform pressure. Because of its shape, the thread will always lie flat in the micrometer. It should measure between 0.0018 and 0.002 inch. When grooves are too shallow, the pickup may slide across the record. Care should be taken that the feed mechanism is adjusted sufficiently level so that the depth of cut remains substantially constant over the entire record.

The cutting stylus should be nearly vertical to the record. Some prefer a lagging angle two or three degrees off vertical, while others favor a leading or "digging in" angle of about two degrees off vertical. Laboratory tests have shown a slight lag or lead to be superior to an exactly vertical stylus in producing a highly polished groove. This applies to sapphire styli in particular.

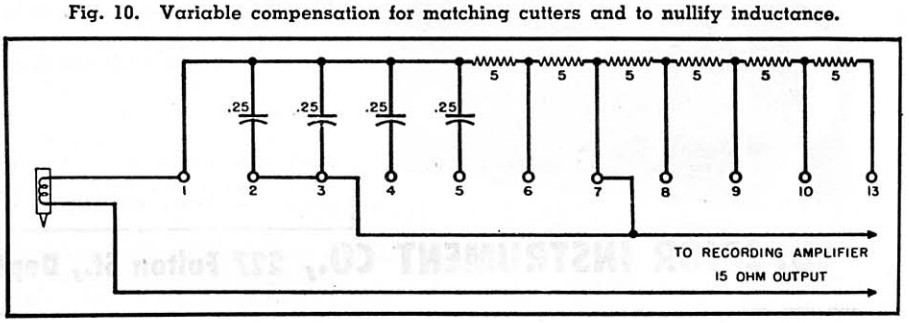
When using professional recording heads, it is well to make surface noise tests and high frequency response measurements with all the styli which are on hand, selecting those that produce quiet, clean cuts. There should be a reasonable number of spare points available to prevent unnecessary use of worn styli. Noise tests from time to time will indicate the condition and degree of wear of the stylus. This can be accomplished by cutting unmodulated grooves with each stylus and measuring the relative noise output, using the high fidelity pickup and a volume indicator preceded by a 1000 cycle high pass filter. High frequency response measurements on styli can be made on one frequency, (for example, 8000 c.p.s.,) and the relative reproduced output noted. For this and the noise measurements recording tests should be made as closely as possible at the same diameter on the disc. The results change rapidly with surface speed.

Determining Recording Level

It is impractical to make a plain statement of the correct recording level for any head. While sensitivity of the heads does not vary more than 2 db., the correct level can be established only by experience and tests. There are no fixed boundaries for disc recording representing 100% modulation. At low frequencies, it is true that the groove spacing limits the amplitude. At higher frequencies, the wave slope is the limiting factor. This slope varies with applied voltage and with record surface speed.

The correct maximum recording level is governed by a number of factors; the subject matter being recorded, the energy distribution with respect to the frequency, whether high frequency needle loss compensation is used, the record surface speed, the type of pickup to be used, the type and length of recording stylus, the type of indicating meter used and its dynamic characteristics, whether peak or average reading is used, the accuracy of program monitoring, the uniformity of average program levels,

Fig. 10. Variable compensation for matching cutters and to nullify inductance.



Thousands of Satisfied Users!

TRANSVISION

TELEVISION KIT . . . A High Quality TELEVISION RECEIVER

ready for Easy, Rapid Assembly

Features the Brilliant LECTROVISION Picture Tube!

ENGINEERED BY TELEVISION SPECIALISTS



Easy-to-Assemble: No knowledge of television required. COMPLETE easy-to-follow INSTRUCTION SHEET gives you all the knowledge you need.

This Kit INCLUDES SOUND, all component parts, and the following:—

Specially designed Television Antenna . . . A $30.00 Brilliant Lectrovision seven-inch Picture Tube, plus ALL other tubes . . . Pre-tuned R-F unit . . . Finished front panel . . . All solder, wire, and 60 ft. of low loss lead-in cable.

Operates on 110V.; 50-60 cycles A.C. Price: complete with ALL tubes, $159.50 (fair traded)

IMMEDIATE DELIVERY!

We believe that the comparative quality of this set is superior to other available sets. It has been acclaimed by major television schools.



CABINET for TRANSVISION Television Kit

Made of selected grain wood, with beautiful hand-rubbed walnut finish. Labeled knobs. Overall size: 17⅛" deep; 19¼" wide; 15⅜" high. *Price: $29.95*

DEALERS! Cash in on this Kit! Ideal for making your own Custom-Built Television Receiver. *See your local distributor, or for further information write to:*

TRANSVISION, INC. Dept. R. N.
385 North Ave. New Rochelle, N. Y.

whether limiting amplifiers are used, temperature of the studio, type of recording blanks, and how much distortion the user is actually willing to tolerate.

It is not difficult to find the correct operating levels for a complete installation by making test cuts of speech and music at the slowest record speed and smallest diameter that can be used. These tests should be made at gradually increasing levels and the results noted upon reproducing. When the reproduced sound ceases to be clear from a quality standpoint, the maximum level has been exceeded. The presence of barely perceptible distortion is sometimes less objectionable than high surface noise which is one reason, from a practical commercial angle, for not being too strictly guided by measured distortion. The proper volume indicator and attenuator setting can then be marked. In cases where an accidental change in gain of a recording amplifier might occur, a volume indicator or voltmeter should also be used at the output terminals.

Broadcast records at 33.3 r.p.m. cannot be cut at as high a level as those for 78 r.p.m. service because of increased wave steepness resulting from reduced surface velocity of the record material. The difference in velocity, roughly 2½ to 1 for a given diameter, makes it necessary to hold down the recording level at least 6 db. on 33.3 discs.

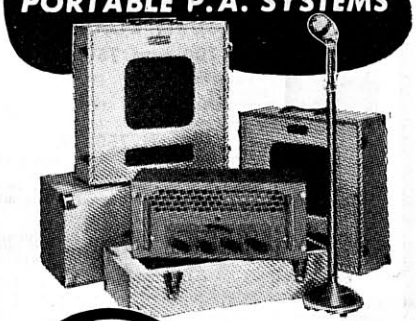
A higher level is usually maintained for 33.3 lacquer master discs for processing than when the original is to be played back repeatedly, as high level, soft lacquer records will not stand up. Furthermore, surface noise of the direct cut disc is low and there is no need for the maximum level. Obviously, in a busy transcription department a variety of recording levels cannot be observed and a compromise level usually results. Whenever there is compromise, the maximum quality cannot be reached in each type of service. Most commercial transcriptions are cut at too high a level from the standpoint of distortion. This distortion is usually due to failure of the reproducing point to track properly because of the steep wave fronts and the departure of the reproduced wave form from the original because the original groove was made with a flat, plain surface but is reproduced with a spherical needle.

When attempting to duplicate (on lacquer discs) the level found on regular studio transcriptions, one should observe the same precautions against overmodulation that were used in making the transcriptions. This means careful control of levels and a simultaneous duplicate recording at a lower level to be used in case the louder one is over cut. By following the same procedure, one will be safe in attempting to equal these levels.[2]

(To be continued)

[2] High Fidelity Recording Head MI-4887 manual, RCA Manufacturing Co., Inc., Camden, N. J., U. S. A.

IMMEDIATE DELIVERY!
PORTABLE P.A. SYSTEMS





MODEL WE-220
5 to 500 Watt Sizes In Portable, Semi and Mobile

Complete Line of Centralized and Portable P. A. Systems, Recorders, Record Players, Combinations, Inter-Communication Equipment and Accessories

Factory Sales Engineer and Display at Congress Hotel during the Show

Visit Us in Our New Enlarged Factory and Showroom.

805 So. Fifth St. Milwaukee, Wisconsin

WESTERN SOUND & ELECTRIC LABORATORIES, INC.
MILWAUKEE, WISCONSIN
Pioneer Manufacturers of Centralized, Portable and Recording and Inter-Communication systems.

WANTED!
Articles by Radio Amateurs
2000 to 2500 words

Covering any material of genuine interest to radio amateurs, such as:

- **Transmitters**
- **Receivers**
- **Antennas**
- **Test Equipment**

Articles should be typewritten (double spaced) and accompanied by suitable diagrams, photos, and parts lists. Liberal payment will be made upon acceptance.

Address all communications to
Box 419
RADIO NEWS
185 North Wabash Avenue
Chicago 1, Illinois

The RECORDING and REPRODUCTION of SOUND

By OLIVER READ
Editor, RADIO NEWS

Part 5. The crystal cutter; its construction, capabilities, and applications for "constant amplitude" and "constant velocity" recording.

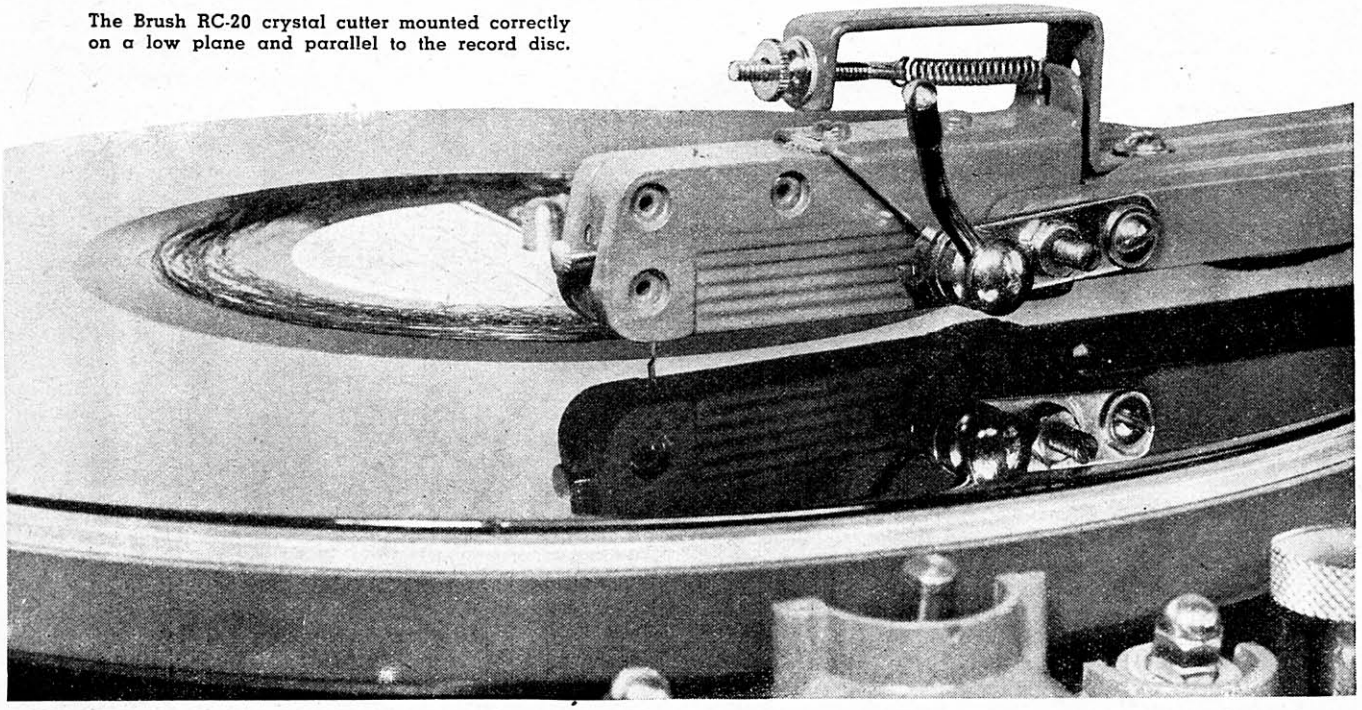
IN ORDER to fully understand the capabilities of the crystal type cutter, it is well to first understand the difference between *"constant amplitude"* and *"constant velocity"* recording. The magnetic cutters previously described are essentially *constant velocity* devices. Crystal cutters, on the other hand, may be adapted for either constant amplitude recording or constant velocity recording. There are certain advantages to each method as will be explained.

One of the most serious limitations today to good quality reproduction from disc records is surface noise, also referred to as needle scratch. This not only produces an irritating effect, but has restricted the range of frequencies which could be reproduced if quieter conditions existed.

Measurements show that the noise components of disc records are definitely more pronounced in the higher frequency spectrum than in the lower regions. They are caused mainly by tiny irregularities in or on the record surface in the form of abrasives, grain, dust, dirt, etc. These irregularities, which are of random distribution, transmit scratch vibrations to the stylus of the phonograph pickup. Surface noise has been effectively reduced in some cases through the use of scratch filters in reproducing circuits or in newer systems such as the *Scott Noise Suppressor*. This method of noise reduction has many advantages. Former methods, however, accomplished the above only with a decrease in high frequency response usually above 3000 cycles per second. This results in a so-called "mellowness," which some people prefer, but it cannot be considered good quality.

Some of the recent records made, particularly for radio transcription and sound studio use, are pressed from cellulose acetate or vinylite. Others are made by cutting directly on cellulose nitrate. The surface noise of these records is considerably reduced because of the smoothness of the material, and the fact that no abrasive has been added. These records are made under very accurately controlled manufacturing processes. Such records have provided from 15 to 20 db. improvement in signal-to-noise ratio over commercial shellac pressings. For best quality results, it is necessary to have these records reproduced with high fidelity phonograph pickups employing permanent jewelled styli of

The Brush RC-20 crystal cutter mounted correctly on a low plane and parallel to the record disc.



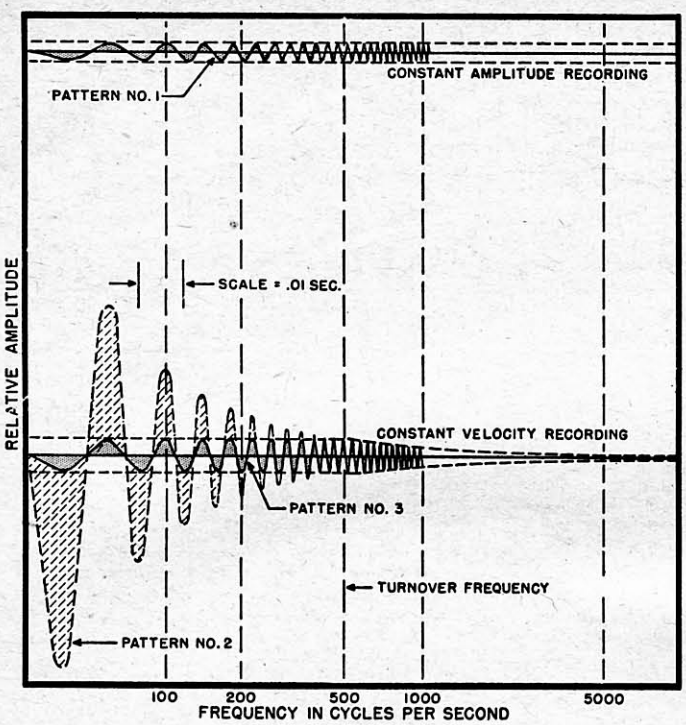


Fig. 1. Wave patterns for "constant amplitude" versus "constant velocity" recording.

optimum shape. In most cases a sapphire is used because of its smoothness and hardness.

While these quieter materials and improved methods of record manufacture contribute considerably to the reduction of surface noise it seems logical, since the noise components are more pronounced in the higher frequency spectrum, that additional noise reduction can be obtained by providing a higher signal-to-noise ratio in this range during recording. This consists of increasing the amplitude of the higher frequency undulations in the record in such a manner that they are considerably higher than those created by the tiny irregularities in or on the record surface. This, of course, takes into consideration that during final reproduction the same relationship which existed in the original sound between the high and low frequency amplitudes will be maintained.

This method of noise reduction can be accomplished effectively through "constant amplitude" recording by using crystal cutters in recording and crystal pickups in reproduction.[1] Due to the inherent characteristics of these devices, this type of noise reduction requires no equalization in either the recording or reproducing circuits. It should be pointed out, however, that this sets a new standard in cutting and does not compare with the characteristics as found on commercial phonographs. Therefore, discs cut constant amplitude should be played back only through proper systems and are not generally interchangeable with other types of amplifiers and reproducing systems.

Before discussing the advantages of constant amplitude recording, it may be well to explain how this method differs from constant velocity recording. In constant amplitude recording[2], constant sound pressure for all frequencies at the microphone (assuming an over-all uniform frequency characteristic up to the cutter) is represented by the same amplitude in the undulations cut in the record. Under these conditions constant velocity recording is represented by the same vibrational velocity, that is, the amplitude of the undulations cut in the record is inversely proportional to the frequency, viz.: Amplitude = Velocity/Frequency, but since the velocity is constant this may be written as Amplitude = K (constant)/Frequency.

In Fig. 1, which represents constant amplitude recording, it will be noted that the amplitude of the groove undulations (pattern No. 1) is constant regardless of the frequency. In pattern No. 2, which represents constant velocity recording, it will be noted that the amplitude of the groove undulations decreases as the frequency increases in such a manner that a frequency of 10,000 c.p.s. has only 1/100 the amplitude of 100 c.p.s. Wave patterns are shown which represent groove undulations for both methods of recording. These wave patterns, for purposes of illustration, are shown with progressive increase in frequency.

Since this method (pattern No. 2) would necessitate excessive amplitudes at the lower frequencies to obtain sufficient amplitude at the higher frequencies for satisfactory reproduction, commercial constant velocity records are usually cut constant amplitude from the lowest frequencies up to approximately 500 c.p.s., as indicated in pattern No. 3. This frequency is usually referred to as the "turnover" frequency. This is also done to permit more grooves to be recorded without danger of crossover or echo effect.

Assuming that for average recording the amplitude for a frequency of 1000 cycles will be the same for constant velocity and constant amplitude recording, then the amplitude for a frequency of 5000 cycles for constant velocity recording will be only 1/5 the amplitude for constant amplitude recording. This, of course, takes into consideration that the cutters used in both methods of recording have a uniform characteristic, at least up to 5000 cycles per second.

It is apparent from the above that constant amplitude recording has an advantage over constant velocity re-

Fig. 2. (A) Microphone (generator) and (B) headphone (motor) action.

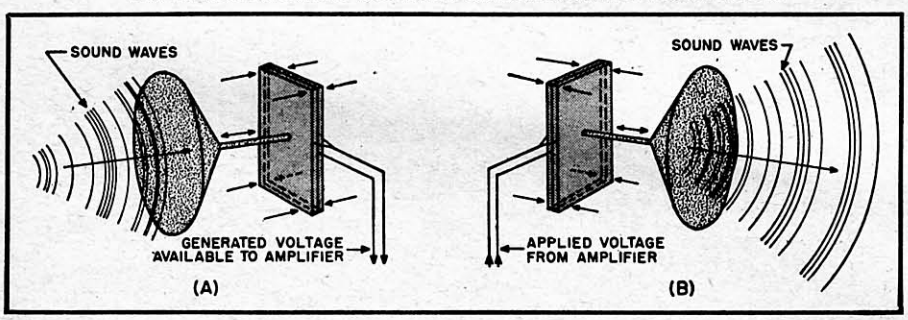
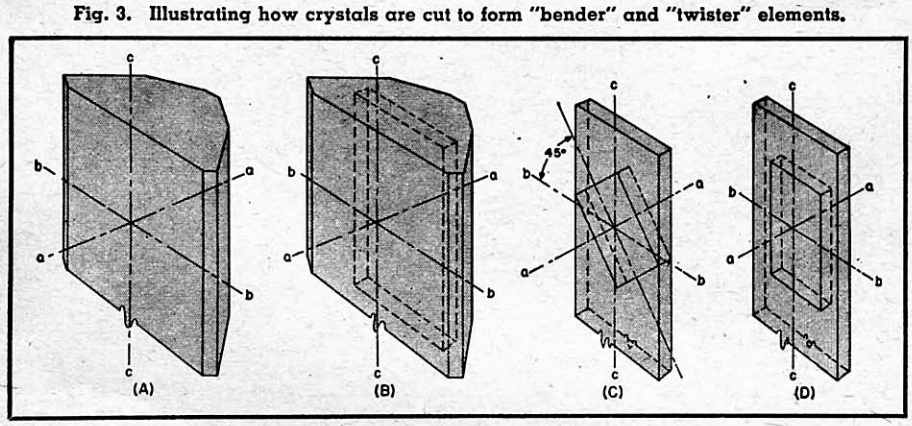


Fig. 3. Illustrating how crystals are cut to form "bender" and "twister" elements.



[1] Read, Oliver, "Build Your Own Recording Studio," Radio News, April, 1941.
[2] Technical Bulletin No. 291, "Brush RC-20 Cutter," Brush Development Co.

cording since the cutter automatically provides the higher amplitudes at the higher frequencies required for noise reduction during reproduction.

The crystal cutter such as the *Brush Model RC-20,* illustrated, is well suited for constant amplitude recording since its stylus displacement (amplitude) is proportional to the input voltages over its useful frequency range. Furthermore, due to the inherent stiffness of the crystal element, the amplitude and frequency response are practically unaffected by depth of cut and variations in hardness of recording materials. Considerable noise reduction also takes place in reproduction since the output voltages, as generated by the higher frequency sound undulations in the record, are considerably greater than the output voltages generated by the tiny irregularities in or on the record material. While it might appear that these higher amplitudes might interfere with the reproducing stylus tracking the grooves at these higher frequencies, this defect can be practically disregarded considering the fact that both speech and musical sounds contain much less energy for the higher frequencies than they do for the lower frequencies. Furthermore, high fidelity crystal pickups are available with low vibratory inertia and styli of small radius of curvature which are capable of tracking high frequency undulations of rather high amplitude.

It is impractical to give definite values of noise reduction resulting from constant amplitude recording since the surface noise in disc records, due to the random distribution of the surface irregularities, varies in degree and frequency spectrum. In general, constant amplitude recording has provided noise reduction of from 6 to 10 db., as compared to commercial constant velocity recording using the same type of recording materials. In subjective tests, because of the irritating nature of the surface noise, this noise reduction appears even greater.

Characteristics of Crystal Elements

Certain crystalline substances exhibit the phenomenon of piezo- (pressure) electricity, i.e., when they are stressed mechanically an electric charge is produced and, conversely, when a voltage is applied, mechanical deformation of the crystal takes place[3].

In the first case, the piezoelectric crystal may be likened to a generator since it converts mechanical motion into electricity. Crystal microphones and phonograph pickups (Fig. 2A) are common examples of piezoelectric generators. In the second case, the piezoelectric crystal may be likened to a motor (Fig. 2B) since it converts electricity into mechanical motion. Crystal headphones and record cutters are good examples of the latter.

Considerable research has been done in developing the piezoelectric crystal for use in sound and other devices.

Such crystals are of the common crystalline form of Rochelle salts (sodium potassium tartrate). These crystals possess piezoelectric properties to a greater extent than any other known material, being approximately 1000 times more active than quartz crystals. The crystals are first grown in large, clear homogeneous bars about two feet long. These bars are cut into slabs and then into the small plates used in the final crystal elements.

The properties of these crystal plates may be expressed in terms of three axes, *a, b,* and *c,* as shown in (A) of Fig. 3. The more common crystal plates are cut perpendicular to the *a* axis because in Rochelle salt

(*Continued on page* 130)

[3] Technical Bulletin No. 310, Brush Development Co.

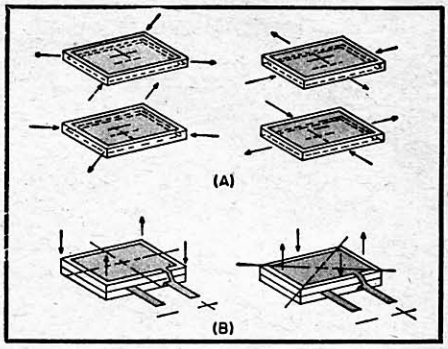


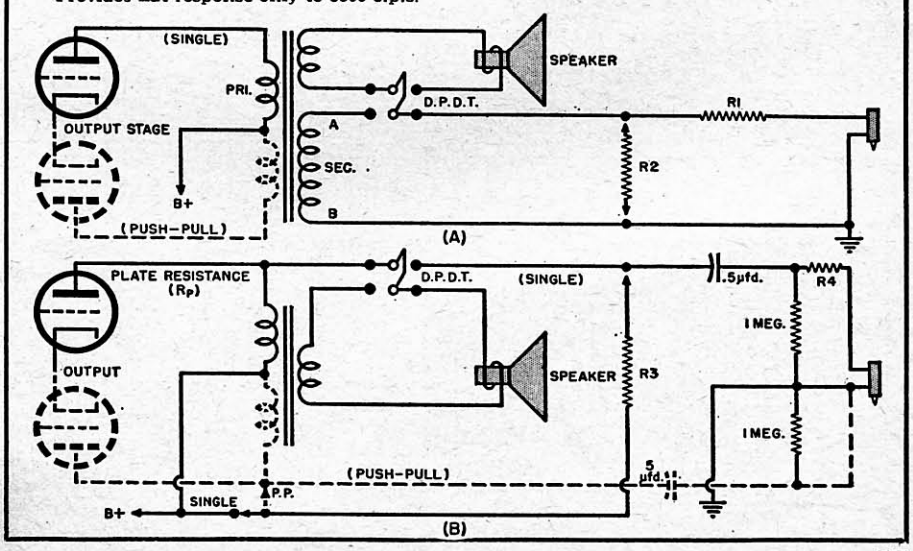
Fig. 4. (A) Single electrode plates in relative pre-assembled positions. Arrows show directions of maximum instantaneous strains for the indicated applied voltage polarity. (B) Arrows show location and direction of maximum motion of the element relative to the indicated axis.

Fig. 5. (A) Schematic diagram shows cutter connected across transformer secondary. (B) Diagram shows how cutter may be connected directly across plates of output tube. Table shown gives component values for either constant amplitude or constant velocity recording. Class "A" or "AB" single or push-pull output tubes should provide an undistorted output of at least 3 watts.

METHOD OF RECORDING	TRIODES	PENTODES OR BEAM POWER (With Stabilized Feedback)	PENTODES OR BEAM POWER (Without Stabilized Feedback)
"Constant Amplitude" (See Fig. 5A)	R_1—Omit R_2—Omit Sec.—Select transformer so that reflected impedance at A-B is not over 4000 ohms.	R_1—Omit R_2—Omit Sec.—Select transformer so that reflected plate impedance at A-B (as modified by feedback) is not over 4000 ohms.	R_1—Omit R_2—3000 to 4000 ohms. Sec.—Select transformer for load impedance at A-B of 3000 to 4000 ohms.
"Constant Amplitude" (See Fig. 5B)	R_2—Omit R_1—Omit *R_p—Not over 4000 ohms.	R_2—Omit R_1—Omit *R_p (Effective)—Not over 4000 ohms.	R_2—Recommended load impedance of vacuum tube. R_1—Omit R_p—Select vacuum tube so that recommended load impedance is not over 7000 ohms.**
Commercial "Constant Velocity" (See Fig. 5A)	$R_1 = \frac{1}{2} Z_T$ (See Fig. 7) R_2—Omit Sec.—Select transformer so that reflected plate impedance at A-B is equal to $\frac{1}{2} Z_T$. (See Fig. 7)	$R_1 = Z_T$ (See Fig. 7) R_2—Omit Sec.—Select transformer so that reflected plate impedance at A-B (as modified by feedback) is equal to $\frac{1}{2} Z_T$. (See Fig. 7)	$R_1 = \frac{1}{2} Z_T$ $R_2 = \frac{1}{2} Z_T$ (See Fig. 7) Sec.—Select transformer for load impedance at A-B equal to R_2.
Commercial "Constant Velocity" (See Fig. 5B)	R_2—Omit $R_1 = Z_T$ (See Fig. 7)	R_2—Omit $R_1 = Z_T$ (See Fig. 7)	R_2—Recommended load impedance of vacuum tube. $R_1 = Z_T$ (See Fig. 7)

*In case of push-pull, R_p equals plate resistance of both tubes.

**Provides flat response only to 3500 c.p.s.



GRAY *Improved* PLAYBACK ARM



This Playback Arm developed 10 years ago by our engineers has been carefully redesigned to comply with the requirements of recent advancements in the art of high-quality reproduction. Now made of magnesium, mass has been reduced to a minimum. Yet the construction retains that solidity, stiffness, frictionless motion, and freedom from undesired resonances, so necessary with new modern low-mass highly compliant pickup cartridges.

With your favorite cartridge, such as the new G. E. Variable Reluctance, mounted in this Playback Arm you can be certain that you are obtaining optimum performance from your equipment with practically no wear on your finest records and transcriptions. Tracking problems have been virtually eliminated.

Features of the new Gray Improved Playback Arm include finely controlled adjustment of stylus pressure, virtually frictionless lateral and vertical bearings, three-point adjustable mounting for accurate leveling, extremely low basic resonance, concentration of lateral mass at stylus, minimum tangency errors, very low vertical inertia, convenient finger-lift near stylus for ease of cueing, and precision construction throughout.

The Gray Playback Arm, designed to take any modern pickup, may be purchased with or without a cartridge. Mounting radii of the three styles are consistent with dimensions of transcription tables. Model 103S illustrated, 13" mounting radius. $35.00.

WRITE FOR ENGINEERING BULLETIN B-10 describing the complete line of Gray professional recording and transcription equipment.



GRAY RESEARCH & DEVELOPMENT CO.

ELMSFORD • WESTCHESTER COUNTY • NEW YORK

B 19 SET OWNERS

AUTHENTIC REPLACEMENT PARTS And SERVICE DATA FOR MARK II And III NOW AVAILABLE!

B 19 TRANSMITTING AND RECEIVING SETS
Complete with all spare parts. Write for prices.

MICROPHONE Dynamic, moving coil type. Impedance 50 OHMS. Diameter 1¾". Button only $0.89

TRANSFORMER To match above microphone. PRI. 50 OHMS. Sec. 125000 OHMS. Size 1⅜x1⅛x1⅛" ..... .59

SPEAKER Dynamic. Impedance 29 OHMS. 2" diameter. Ideal for small rec., intercom, or pillow speaker ..... .79

TRANSFORMER To match above speaker. Size: 2½x1⅜x¾" ..... .59

RELAY 4 pole double throw 4 break 4 make. Silver contacts. DC resistance 100 OHMS. Size: 3¾x1x2⅛". Operates between 4 & 8 volts.... .79

U. H. F. CAPACITOR Dual variable ceramic, two stator, one rotor, per section. Front sec. 2.9 MMF to 6.8 MMF. Rear sec. 2.5 MMF to 6.4 MMF..... .79



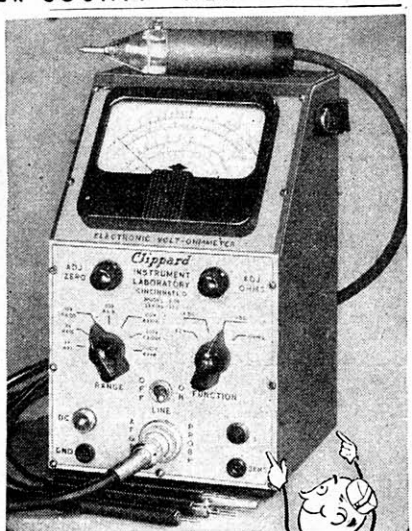
CORD 5½ Ft. 2 conductor, rubber covered with PL-55 phone plug and Jack JK-26. **$0.39**



CORD 7 FT. 3 conductor, rubber covered with PL-68 mic. plug, DPST. Bakelite palm switch and JK-48 socket. **$0.39**

25% Deposit required on C.O.D. orders.
Shipped F.O.B., Lima, Ohio Minimum Order $2.00

FAIR RADIO SALES
223 S. MAIN ST. • LIMA, OHIO



Clippard

ELECTRONIC VOLT-OHMMETER, MODEL 406

We invite comparison of this instrument with any at any price for appearance, ruggedness, accuracy, stability. 0-1 to 1,000 volts U.H.F., A.C., D.C. 0-1,000 megohms. Pen-type dual-diode A.C. probe. No extras to buy. Send for details or order today.

$89.50 NET From Jobber or F.O.B. Cinti.

CLIPPARD INSTRUMENT LAB., INC.
1125 Bank St., Dept. 9, Cincinnati 14, Ohio

the electric effects along this axis are by far the most pronounced. The two fundamental "a-cut" plates used are the expander and shear plate shown in (C) and (D) of Fig. 3. It will be noted that the expander plate is cut at a forty-five degree angle to the *b* and *c* axes and the shear plate is cut with edges parallel to the *b* and *c* axes.

When a voltage of given polarity is applied to the two faces of each plate, the mechanical motions developed will be at forty-five degrees to the *b* and *c* axes. This means that the expander plate shown in (C) of Fig. 3 will increase its length and simultaneously decrease its width. These two actions reverse on change of polarity of the applied voltage The cut of the shear plate (D) of Fig. 3 shows that a similar action occurs but that expansions and contractions occur approximately along the diagonals of the plate instead of in directions parallel to the edges, as in the case of the expander plate.

Two or more crystal plates properly oriented with respect to each other are cemented together to provide more efficient utilization of the piezoelectric properties of the crystal. Two or more expander plates when cemented together form a *bender* element and two or more shear plates when cemented together form a *twister* element. These names "bender" and "twister" have been selected since they indicate the resulting motion of the final element when an electrical potential is applied.

Both bender and twister elements, because of their multiple plate construction, are further classified as "Bimorphs." This type of construction has the advantage over the single plate crystal of practically eliminating the generally undesirable effects of saturation and hysteresis and of greatly reducing the effects of temperature on sensitivity and impedance. Construction of the bender and twister "Bimorph" elements are shown in Fig. 4A. Prior to the final assembly, the two faces of each crystal plate are milled smooth and graphite or foil electrodes are applied. Metal leads are connected to the electrodes and the plates, after proper orientation, are bonded together with a cement. The electrodes are connected either in parallel or in series, depending on the application for which the final element is constructed. The parallel lead arrangement, however, is standard and is shown in Fig. 4B. The assembled crystal element is finally coated with a specially prepared moisture-proofing material for protection against deterioration in unusually dry or damp conditions of use.

Rochelle salt crystals operate safely from —40 to +130 degrees Fahrenheit. They have their greatest piezoelectric activity at normal room tem-

perature, 72 degrees Fahrenheit. Upon exposure to temperatures higher than 130 degrees Fahrenheit, the crystals lose their piezoelectric properties permanently. The voltage developed by the crystal elements for a given stress remains constant over the temperature range provided that the load impedance for all conditions is much higher than the crystal impedance. This generated voltage is practically proportional to the applied stress. Conversely, the amplitude of motion produced when the crystal is used as a motor, is also practically proportional to the applied voltage.

In the design of circuits using crystal devices, the crystal element may be considered as a pure capacity.

Operation of a Crystal Cutter

A well designed crystal cutter is capable of producing excellent records. It has a wide and uniform frequency response and is practically free from harmonic distortion. Exceptionally efficient in operation, it permits the use of a driving amplifier of relatively low power output[2].

Because of the inherent stiffness of the crystal and stylus arrangement, the amplitude and frequency response are almost completely unaffected by depth of cut and variations in hardness of recording materials.

Since this cutter is of the crystal-actuated type, the stylus displacement (amplitude) is proportional to the voltages impressed across its terminals over practically its entire frequency range. For this reason, constant amplitude records can be cut without any form of equalization. If desired, commercial constant velocity records may be cut merely through selection of proper coupling circuits to the driving amplifier. The frequency response characteristic is substantially uniform from 50 to 9000 c.p.s.

When connected to the output of an amplifier, the cutter represents a capacity load in which the impedance decreases as the frequency increases. For this reason, it is recommended that a Class "A" or "AB" power amplifier employing triode output tubes be used since the harmonic distortion generated in these tubes is relatively independent of load conditions. Power amplifiers employing pentode or beam power tubes may be used providing they employ a stabilized feedback circuit in the output stage and that the output is shunted with a resistance of suitable value to stabilize the load impedance. Suitable amplifiers will be covered in later articles.

Figs. 5A and 5B show representative circuit arrangements for triode, pentode, and beam power output tubes. These may be connected in single or push-pull arrangement, although the latter is preferable from the standpoint of reducing distortion in the output stage. These diagrams also show connections for loudspeakers in case these may be required for reproducing purposes. The output tubes should be selected to provide an undistorted

BA BARGAIN SPECIAL



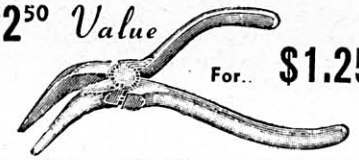
RG-8/U Flexible Coaxial Cable
50 FOOT COIL
Fittings Included ONLY $1.95
Yes Sir—its the standard Amphenol RG-8/U—52 ohm impedance Coax Cable, complete with Amphenol 83-1SP (PL259) connectors on each end, and an 83-1J (PL258) junction, so you can readily connect together as many 50 ft. coils as you wish for any desired length. Fittings alone are regularly worth far more than the price asked for the complete assembly BRAND NEW PERFECT. $1.95
No. 4A497, Per Coil with Fittings.....
No. 2A163, RG-8/U in Bulk, Per ft. 7c
In Lots of 100 feet and over, per ft..... 5c

$8.00 SOLDERING IRON
For Only..... $2.95



200 Watt, Hex-A-Con Model 201
The ideal iron for all around work. Elements wound from Nickel-Chrome resistance wire—plug type 5/8" drawn copper tip, tinned ready for use—approved cord, rubber plug and cord spring. Hurry! Limited Quantity on Hand.
No. 16A400 Special Each..... $2.95

$2.50 Value
For.. $1.25



CURVED NEEDLE NOSE PLIERS
6" Cresent Tool Co. Drop forged "Crestoloy" steel, cadmium plated. Very handy for close quarters. At this price, every tool kit and bench should have one
No. 16A376. Limited Quantity, Special Each $1.25

Dynamic Hand MIKE
AT LESS THAN HALF PRICE



High impedance type—with press-to-talk switch that shorts microphone when released and operates a relay or other circuit when depressed. Designed for close talking PA and mobile communications services. Speech is crisp and clear
Made to stand rough handling. Black wrinkle finished. Has 6 ft. 3-conductor shielded rubber covered cable and standard Amphenol plug. Made by Electro-Voice for Signal Corps. Every One BRAND NEW, Perfect. Comparable Mikes List at $28.00
No. 17A408 Special Each..... $7.95

ORDER NOW, from this ad while these Outstanding Values are still available.
Our terms Cash with order or COD with 20% deposit please. Add Postage

HANDSET TS13
Combines a 200 ohm carbon mike and 2500 ohm ear phone with butterfly switch for "listen" and "talk". Has 6 ft. flexible rubber cord with 1 each PL55 and PL68 plugs attached. Attractive bakelite case, light weight.
Ideal for interphone outfits for home or industry, mobile and many other applications. Made to rigid Signal Corps spec.



A Truly Outstanding Surplus Bargain. Every One BRAND NEW.
No. 17A407, Special Each. ... $3.95

12½ Ft. ANTENNA
TELESCOPES DOWN to 1 Foot 4"



"Just it" for mobile equipment, portable receivers and transmitters. Ruggedly constructed—smooth telescopic action from 16 inches to 12½ feet. Base is 7/8" in dia. with 3/8" threaded shank.
An Outstanding Value
No. 38A39, Only... ... $1.95

Compact Rechargeable STORAGE BATTERY



Willard 2 Volt in Spill-Proof Clear Plastic case Only 2 3/8" square and 6" high—(about the size of the ordinary #6 dry cell) make it applicable for a wide range of uses where battery power is needed Rated at 24 AH
Gangs nicely for other voltages in multiples of 2 volts.
Shipped dry. Uses standard battery electrolyte available everywhere Every One Brand New.
While They Last,
No. 5A133, Special Each ... $1.95

The "Tops" in Headphones
At a Fraction of Original Cost



8000-ohm impedance, highly sensitive. Best quality Alnico magnets in molded black bakelite cases, concealed terminals. Headband fully adjustable, leather covered spring steel 12" cord with PL54 plug attached at side out of way. Jack and rubber cord supplied to extend length to 5½ ft.
Extremely lightweight, only 9 oz., with removable rubber ear cushions of comfortable design Made to Air and Signal Corps specs
Brand New—a 13.50 Value
Stk. No. 17A37, Special Per Pair $2.49

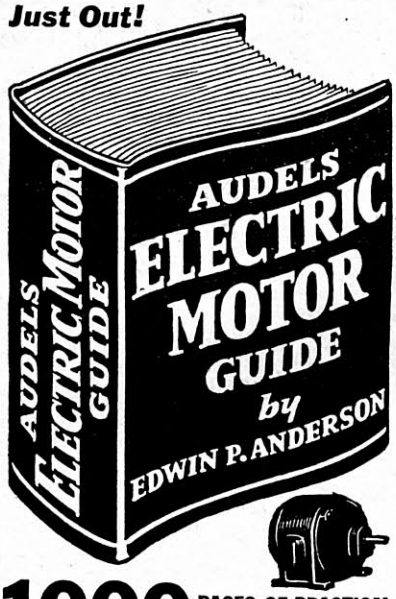
BURSTEIN-APPLEBEE Company
1012-14 McGEE STREET,
KANSAS CITY 6, MISSOURI



Did You Get It?
The New B-A Catalog No. 471

7 Days Free Examination

Just Out!



1000 PAGES OF PRACTICAL MOTOR INFORMATION

AUDELS ELECTRIC MOTOR GUIDE covering the construction, hook-ups, control, maintenance and trouble shooting of all types of motors including armature winding. Explains entire subject in every detail. 31 Chapters, 617 Illustrations & Diagrams. A Handy Guide, Fully Indexed for Electricians and all Electrical Workers.

$4 COMPLETE • PAY ONLY $1 A MONTH

Step up your own skill with the facts and figures of your trade. Audels Mechanics Guides contain Practical Inside Trade Information in a handy form. Fully illustrated and Easy to Understand. Highly Endorsed. Check the book you want for 7 days Free Examination.

Send No Money. Nothing to pay postman.

CUT HERE

MAIL ORDER

AUDEL, Publishers, 49 W. 23 St., NEW YORK 10, N. Y.

Please send me postpaid for FREE EXAMINATION books marked (x) below. If I decide to keep them I agree to mail $1 in 7 Days on each book ordered and further mail $1 monthly on each book until I have paid price Otherwise, I will return them.

- ☐ ELECTRIC MOTOR GUIDE, 1000 Pages . . . $4.
- ☐ ELECTRICIANS EXAMINATIONS, 250 Pages . 1.
- ☐ WIRING DIAGRAMS, 210 Pages . . . . . 1.
- ☐ ELECTRICAL DICTIONARY, 9000 Terms . . . 2.
- ☐ ELECTRICAL POWER CALCULATIONS, 425 Pgs. 2.
- ☐ ELECTRONIC DEVICES, 216 Pages . . . . . 2.
- ☐ RADIOMANS GUIDE, 914 Pages . . . . . 4.
- ☐ HANDY BOOK OF ELECTRICITY, 1340 Pages 4.
- ☐ ELECTRIC LIBRARY, 12 vol., 7000 Pgs., $1.50 vol.
- ☐ OIL BURNER GUIDE, 384 Pages . . . . . 1.
- ☐ REFRIGERATION & Air Conditioning, 1280 Pgs. 4.
- ☐ POWER PLANT ENGINEERS Guide, 1500 Pages. 4.
- ☐ PUMPS, Hydraulics & Air Compressors, 1658 Pgs. 4.
- ☐ AUTOMOBILE GUIDE, 1540 Pages . . . . . 4.
- ☐ DIESEL ENGINE MANUAL, 400 Pages . . . 2.
- ☐ WELDERS GUIDE, 400 Pages . . . . . 1.
- ☐ BLUE PRINT READING, 416 Pages . . . . . 2.
- ☐ SHEET METAL WORKERS Handy Book, 388 Pgs. 1.
- ☐ SHEET METAL PATTERN LAYOUTS, 1100 Pgs. 4.
- ☐ AIRCRAFT WORKER, 240 Pages . . . . . 1.
- ☐ MATHEMATICS & CALCULATIONS, 700 Pgs. . 2.
- ☐ MACHINISTS Handy Book, 1600 Pages . . . 4.
- ☐ MECHANICAL Dictionary, 968 Pages . . . . . 4.
- ☐ MARINE ENGINEERS Handy Book, 1280 Pages 4.
- ☐ MECHANICAL DRAWING GUIDE, 160 Pages . 1.
- ☐ MECHANICAL DRAWING & DESIGN, 480 Pgs. 2.
- ☐ MILLWRIGHTS & Mechanics Guide, 1200 Pgs. 4.
- ☐ CARPENTERS & Builders Guides (4 vols.) . . 6.
- ☐ PLUMBERS & Steamfitters Guides (4 vols.) . 6.
- ☐ MASONS & Builders Guides (4 vols.) . . . . 6.
- ☐ MASTER PAINTER & DECORATOR, 320 Pgs. 2.
- ☐ GARDENERS & GROWERS GUIDES (4 vols.) 6.
- ☐ ENGINEERS and Mechanics Guides Nos. 1, 2, 3, 4, 5, 6, 7 and 8 complete . . . 12.
- ☐ Answers on Practical ENGINEERING . . . . 1.
- ☐ ENGINEERS & FIREMANS EXAMINATIONS . 1.

Name_____

Address_____

Occupation_____

Employed by_____ RN

power capacity of a least 3 watts.

Since the impedance of the cutter will decrease as the frequency increases, this means that if the cutter impedance is high with respect to its coupling circuit over its entire frequency spectrum, the cutter will operate on a constant amplitude basis.

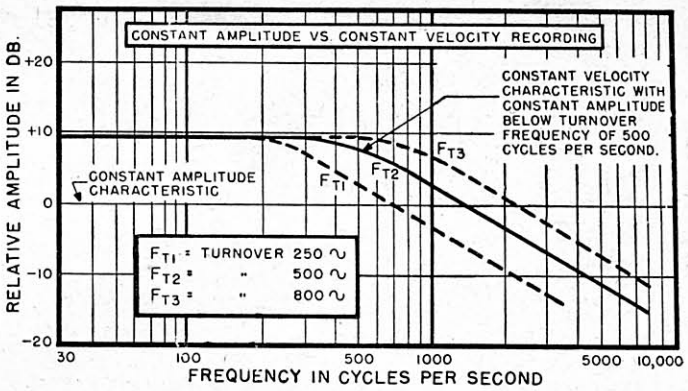


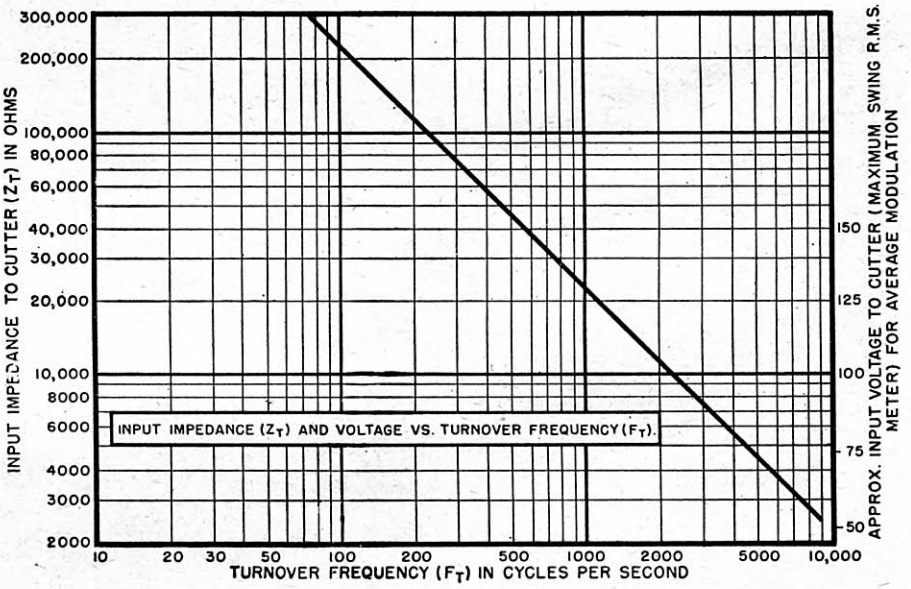
Fig. 6. Curve shows relative amplitude in db. in relation to frequency in c.p.s. for constant amplitude and constant velocity recording.

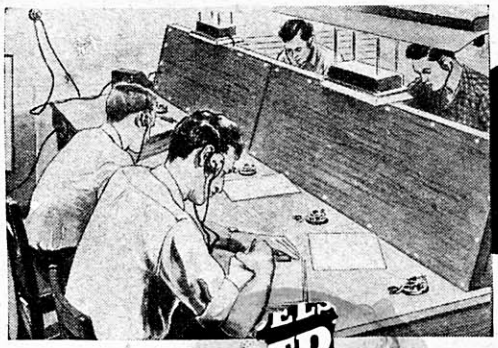
When the cutter impedance equals the impedance of the coupling circuit, its response will be cut down 3 db. at the frequency where these impedances are equal. Above this frequency, or the turnover frequency, the response will fall off at the rate of 6 db. per octave. In other words, the cutter will operate at a constant velocity basis *above* the turnover frequency and at a constant amplitude basis *below* the turnover frequency. By proper selection of circuit components (usually a transformer and/or a series resistor) this turnover can be placed anywhere in the frequency spectrum. If the turnover is located anywhere between 250 and 800 c.p.s., the cutter will engrave commercial constant velocity records. If the turnover is located at the upper end of the frequency spectrum, that is 7000 to 9000 c.p.s., the cutter will engrave constant amplitude records.

The circuit components for engraving either constant amplitude or commercial constant velocity records may be selected in accordance with the table shown in Fig. 5. Typical frequency response characteristics for these two types of recordings are shown in Fig. 6.

In the case of constant amplitude recording, the frequency response on an amplitude basis is uniform throughout the frequency range. These records can be reproduced with pickups (such as the *Brush* Models PL-20, PL-50 and PL-25) without equalization in the reproducing circuit. In the case of commercial constant velocity recording, the frequency response (amplitude basis) is uniform only up to the turnover frequency, usually between 250 and 800 c.p.s. and falls off at the rate of 6 db. per octave above this frequency. These records can be reproduced with the same pickups and other types but equalization is required in the reproducing circuit

Fig. 7. This chart may be used to obtain the input impedance (Z_T) to the cutter for commercial "constant velocity" recording (See table of Fig. 5). This impedance will vary for the "turnover frequency" selected. The cutting voltage required for average modulation of the record on the basis of the "turnover frequency" may also be obtained from this chart. For example: For a "turnover frequency" of 500 c.p.s. the input impedance (Z_T) to the cutter should be approximately 44,000 ohms. This impedance should be divided between the transformer secondary (sec.) and series resistor, R_1, as in Fig. 5A or lumped as a series resistor, R_1, as in Fig. 5B. For a "turnover frequency" of 500 c.p.s. approximately 150 volts is required for average modulation of the record.





OPPORTUNITY KNOCKS FOR RADIO EXPERTS!



Train for YOUR TRIumphant Career Job in Beautiful, Cosmopolitan MIAMI

More and more young men and women are preparing to meet the challenge of modern industry with modern training at Embry-Riddle School of Aviation. Years of experience at this U. S. Government approved school have effected the development of a full year Radio Course that is designed to qualify you for an important position in the Radio industry. A limited number of both civilians and veterans can be accepted for the next class. For complete information fill out the attached Coupon and mail today.

Embry Riddle
SCHOOL OF AVIATION
Miami 30, Florida

Dean of Enrollments—Dept. 16
Embry-Riddle School of Aviation
Miami 30, Florida

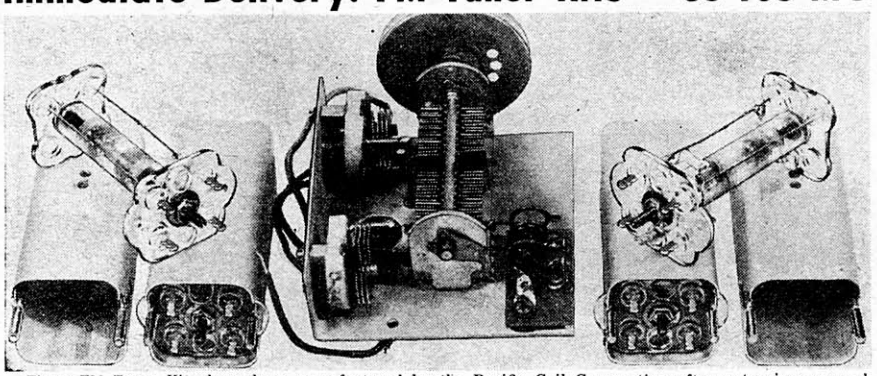
Name_____

Address_____

City_____ State_____

Check One ☐ Veteran ☐ Civilian

Immediate Delivery: FM Tuner Kits — 88-108 MC



These FM Tuner Kits have been manufactured by the Pacific Coil Corporation after extensive research by their Radio Electronic Engineers.

They are made uniform by prealigning and checking on special testing equipment which is built to duplicate actual operation conditions. This assures that all FM Tuners will be ready for wiring with a minimum of effort. Pacific Coil FM Tuner Kits are designed to operate at the adjustment yielding the highest stability, thus holding at an absolute minimum the tendency to drift.

All IF, Limiter and Discriminator coils are wound on low loss Polystyrene forms to assure the highest gain and stability possible.

Foundation Kit complete with Prealigned Tuning Units
Two IF Coils
One Limiter Coil
One Discriminator Coil
Circuit Diagram
Part No. FM—10.....List Price **$24.95**

Complete Kit includes Foundation Kit, as at left, Chassis with all sockets riveted in place, Dial Resistors, Condensers, Hardware, and all other parts to construct a complete FM Tuner.
Part No. FM—11.....List Price **$39.95** Less Tubes

Standard discounts given to Dealers, Servicemen, and Amateurs on all list prices.
Send for our Bulletins of real guaranteed values.

Radio & Television Equipment Company
207 Oak St. Santa Ana, Calif. 709 Cherry St. Long Beach, Calif.



Check Pin Connections & Tube Data Instantly!

Two new and amazingly handy slide rules tell you **at once** the location and nature of pin connections, filament voltage, filament current, and uses for 176 radio tubes. Radio or electronic engineers, servicemen, students can't afford to be without these pocket-sized time-savers. SEND $1.00 IN CASH OR MONEY ORDER TODAY and receive both prepaid by return mail. Your money back if not satisfied.

WRITE FOR QUANTITY PRICES

HARRY LANGSAM,
12 S. 12th Street, Phila. 7, Pa.
☐ I enclose $1.00. Please send both Radio Tube Pin Data Rules.
☐ Send Quantity Prices.

Name_____

Address_____

City_____ State_____

MILES "TELEMIKE"

A midget unit (1¼"x1¼"x1¼") requiring no physical contact to telephone. PICKS UP BOTH SIDES OF TELEPHONE CONVERSATIONS for group loud speaker listening or for recording when used with standard amplifier or recorder. PRICE $25.00 postpaid.

Write for details on our complete line of FILMGRAPH TELEPHONE—CONFERENCE—DICTATION—"TALKIE" RECORDERS & REPRODUCERS.

MILES REPRODUCER CO., Inc.
Dept. RN-7, 812 Broadway, New York 3, New York.

Don't forget to refer to the RADIONIC Catalog!

to provide a uniform response characteristic. Special filters to accomplish this will be covered later.

In many cases where commercial crystal pickups employing steel needles are used, it may be desirable to cut records with a turnover at some higher frequency than for commercial constant recordings. Since many of these pickups have resonant peaks between 4000 and 5000 c.p.s., a turnover at from 1000 to 3000 c.p.s. may produce a more uniform frequency response. It will be necessary to experiment with the turnover frequency to obtain best results. When records with a high turnover are reproduced with crystal pickups, this will result in a uniform response up to the turnover frequency with attenuation of 6 db. per octave above this frequency.

In constant amplitude cutting the actual impedance from which the cutter operates should not exceed 4000 ohms. This may be obtained from an output transformer as shown in Fig. 5A or by connecting directly to the plates of the output tubes as shown in Fig. 5B. In the latter case the plate resistance (R_p) of the vacuum tube (plate resistance of the two tubes for push-pull) should not exceed 4000 ohms. When a uniform frequency range up to 9000 c.p.s is required, constant amplitude recording requires approximately 50 volts for average modulation of the record (maximum swing on r.m.s. meter).

In cutting commercial constant velocity, the impedance from which the cutter operates will depend on the turnover frequency selected. This may be obtained from an output transformer and a series resistor as shown in Fig. 5A, or by connecting to the plates of the output tubes through a series resistor as shown in Fig. 5B. For example, by reference to Fig. 7, it will be noted that where a turnover frequency of 500 c.p.s., is required, the cutter should operate from an impedance of approximately 44,000 ohms. This is the cutter impedance at this frequency. Referring to Fig. 5A, this impedance should be divided between the series resistor and the secondary impedance of the output transformer. Generally, these two may be made equal, viz. 22,000 ohms for a turnover of 500 c.p.s. Resistor R_1 should not be smaller than the reflected resistance of the amplifier at *A-B*, Fig. 5A. In the event that the plate resistance (R_p) for two vacuum tubes in push-pull is 1600 ohms, the output transformer would then have an impedance ratio of 1600 : 22,000 ohms. This corresponds to an impedance ratio of approximately 1 : 13.8 or a turns ratio of 1 : 3.7. Since such an odd ratio transformer may not be easily obtained one having a turns ratio of 1 : 3.5 or 1 : 4 will be found suitable without shifting the turnover frequency seriously. In selecting the output transformer, it is important that there be a sufficient power handling capacity and uniform frequency characteristics throughout its range. When the turnover frequency is be-

tween 250 and 800 c.p.s. commercial constant velocity recording requires approximately 150 volts (maximum swing on r.m.s. meter) for average modulation of the record. See Fig. 7.

It will be noted in Fig. 6 that in commercial constant velocity recording, the lower frequencies are cut approximately 10 db. higher than constant amplitude recording. Constant amplitude can be cut at a higher level for higher record modulation. However, it will be necessary to reduce the frequency range during recording. This can be accomplished by providing a turnover below 9000 c.p.s. much in the same manner as is done at 250 to 800 c.p.s. in the case of commercial constant velocity recordings. For example, if a turnover is selected at 4000 c.p.s., so that only those frequencies below this point are cut constant amplitude, then the voltage applied to the cutter may be increased to approximately 80 volts, (maximum swing on the r.m.s. meter). Lower turnover frequencies will permit higher voltages to be applied to the cutter for higher record modulation. See Fig. 6.

Mounting the Crystal Cutter

To insure good frequency response and a clean cut of constant depth, the following recommendations should be taken into consideration:

1. The mounting bracket for the cutter should be designed so that the pivot point is fairly close to the record plane so as to minimize the effects of any movement which might develop while cutting, due to forces on the record cutting stylus.

2. The pivot point of the mounting bracket should provide free movement to the cutter in a vertical plane. It should, however, be free of play so as to give a stiff support to the cutter against any vibration caused by the lateral motion of the cutting stylus on the record. Needle point bearings are most suitable for this use.

3. Some means for governing the depth of cut should be provided. This may be accomplished by a spring held under proper tension.

4. The moment of inertia should be reduced to a minimum with respect to vertical motion of the cutter. Any mounting weight which will add to the stylus pressure should be kept at a minimum.

5. The cutter may advantageously be completely enclosed within an arm wherever possible.[2]

(To be continued)

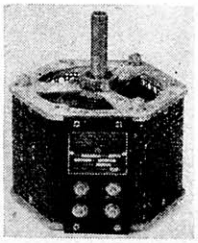
HAMMARLUND HEADS AMATEUR COMMITTEE

LLOYD A. HAMMARLUND, president of the Hammarlund Mfg. Co. of New York, was recently named chairman of the Radio Manufacturers Association Amateur Radio Committee.

Mr. Hammarlund, who succeeds W. J. Halligan as chairman of the committee, will be assisted in this new project by R. C. Sprague, president of Sprague Electric Company who has been named vice-chairman of the committee. -30-

RECTIFIER & BATTERY CHARGER COMBINATION

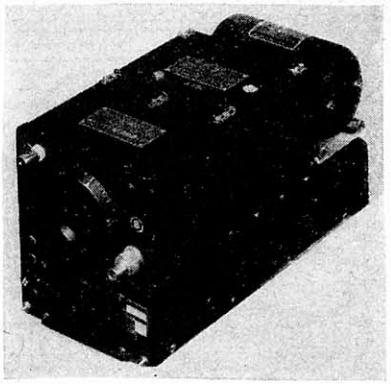
No. RA91A—Selenium plate, full wave 115 or 230v AC; 50-60 cycle, single phase input; output is 6 to 48v DC at 2 to 15 amp; manually controlled, complete with overload input and output switches. 0-15 amp DC meter. Excellent for laboratories, servicemen, service-stations. Shipping weight 150 lbs. Price..... **$39.50**



SUPERIOR 2 KVA POWERSTATS

SUPERIOR 2 KVA Powerstats; input 115 volts 50-60 cycle—output voltage range 0-135 volts; maximum rated output current 15 amp. available over entire range of output voltage; weighs approx. 20 lbs.... **$29.50**

SUPERIOR 2 KVA 3½ KW powerstats 2 in tandem, each 115 volt AC single phase. Same as the above but twice the input and output voltage..... **$54.50**



6 TUBE Brand New Receiver with tubes Only $5.95

Receivers of the SCR-274-N/(AN/ARC-5) Series. All-aluminum aircraft receivers 5″ wide, 8″ high, 12½″ long; weight 6½ lbs. Typical tube line-up is: 12SK7 RF, 12K8 Converter, two 12SK7 IF's, 12SR7 Detector and BFO, 12A6 Output, gas-filled antenna-signal voltage limiter, and gas-filled output signal voltage limiter. Each set comes complete with all tubes in sockets. Item 1: 3 to 6 Meg. less dynamotor; Item 2: 6 to 9.1 Meg. less dynamotor. The dynamotor..... **$1.95**

BEEDE METER, New, in black finish bakelite case, 3″ round; 0-1000 MA DC. While they last only..... **$1.95**

GENERAL ELECTRIC 0-30 DC Milliammeter—3″ bakelite case..... **$3.50**

French Type PHONE TS-13C Hand Set

With butterfly switch on handle. When the switch is pressed, the microphone is connected into the circuit and an additional set of contacts are closed, to operate a changeover relay. Has a 6-ft. length of cord, with a PL 55 plug for earphone and PL 68 for microphone and switch. Impedance of earphone approx. 2500 Ohm; impedance of microphone approx. 250 Ohm (carbon); connected with batteries it can be used for inter-communication system. They are brand new and the original cost is many times what we are offering them to you . . . while they last..... **$3.95**

GENERAL ELECTRIC Tungar Battery Chargers

Model No. 6R-B33B2—1 to 12—6 volt batteries; 6 amp DC 115v AC, 60 cycle; complete with Tungar Bulb. Shipping weight approx. 40 lbs..... **$29.50**

JENSEN P.M. 4″ Speaker; 4 to 6 ohm. All brand new. Special..... **95¢**

CRYSTAL DIODES 1N21B (1N34) See Radio News May issue page 50. Each 50c or 3 for $1.25.

WILCOX F3 6 Tube Receiver $13.95

Brand New, in original carton; complete with set of 3.5 to 6.1 meg. coils and set of spare tubes; 110 VAC 60 cycle. Tubes 2—6K7, 1—6K8, 1—6F7, 1—6C8G, 1—80.



This receiver is equipped with a radio frequency sensitivity control, an audio gain control, automatic volume control and an inter-carrier noise suppressor. The audio amplifier is capable of producing zero level db output across a 500 ohm load.

The F3 Receiver is a crystal controlled superheterodyne receiver consisting of a single stage radio frequency amplifier, an oscillator-mixer, a single stage intermediate frequency amplifier, a second detector and automatic volume control voltage amplifier, and an inter-carrier noise suppressor and audio output stage.

Navy Standard Storage Battery

Brand New

Made by Gould Storage Battery Corp. 6 volt 15 amp hour. Excellent for amateurs, experimenters, radio servicemen, etc. Shipped dry, with complete instructions for charging. 4⅝x4¾x6¾ high. Shipping weight 12 lbs. While they last. **$4.95**

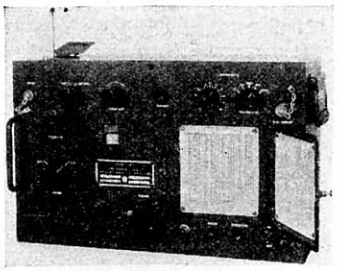


Crystal Calibrated Signal Generator 1-222-A $54.50

Operation from 110-117 volt, 60 cycle source, power consumed 40 watts. Self contained power supply.

COMPLETE WITH TUBES

Within the ranges of the FM and television IF freq and the Police, Taxi, Aircraft, RR. etc. VHF. Instruments are individually hand calibrated and use an accurate vernier-scale planetary dial.



A combination signal generator and heterodyne wavemeter. It consists of a 5 megacycle crystal-controlled oscillator used as frequency standard calibrator, a variable two-range oscillator, an untuned detector with two stages of audio amplification, a sliding-rod stub antenna, a rough pi-type RF attenuator, a frequency calibration chart and a power supply. Coverage of the test oscillator on the low range setting is from 8 to 15 megacycles; the high frequency range coil covers from 45 to 76 megacycles and since the third harmonic is utilized, this gives a coverage of from 135 to 230 megacycles.

The signal generator cabinet measures 19½″ wide, 12″ high, 7½″ deep; weight 50 lbs. Tubes in BC-1298 Power Supply—16—6SN7GT; 1—5V3GT/G; 2—6H6; 1—6SA7; 2—6V6GT; 1—6SJ7. Tubes in I—222-A: 1—6J5; 2—9006; 2—6SJ7; 1—5Y3GT/G. **An additional extra power supply and tubes, with many other small items including cables packed in wooden chest is included in this price. Gross wt. of entire equipment 490 lbs. While they last $54.50**

Prompt Delivery—Write Dept. RNJU
25% deposit required on C.O.D. order
Shipped F.O.B. New York. Min. Order $2.00

MICHAEL STAHL, INC.
39 VESEY ST.
Tel. COrtland 7-5980 New York 7, N. Y.

The RECORDING and REPRODUCTION of SOUND



Wire recorder becomes modern dictating machine

By OLIVER READ
Editor, Radio News

Part 6. Covering the theory and practice of various methods employed in magnetic recording on wire, tape, and non-metallic, magnetically coated materials.

PRESENT methods of sound recording by magnetic means are the result of discoveries of Valdemar Poulsen, a Danish scientist, who, in 1898, experimented with magnetic recording on wire.

It is well known that hard steel can be magnetized to form a bar magnet as in Fig. 1A. It is not as well known, however, that the same bar can also be magnetized as in Fig. 1B, with a north pole at each end, and a south pole at the center. This idea is carried still further in Fig. 1C, which illustrates magnetic poles unequally spaced, and of different strength. It can be shown that within limitations, to be described later, it is possible to form a magnetic pattern corresponding to any desired wave shape.

Suppose that a magnetized bar, such as shown in Fig. 2, were to be pulled at uniform speed through a rather closely fitting coil, in accordance with Faraday's Law of Electromagnetic Induction, there would be an e.m.f. across the coil which is:

$$E = N\, d\phi/dt \text{ abvolts}$$

where:

E is the induced e.m.f.
N is the no. of turns in the coil.
$d\phi/dt$ is the time rate of change of flux.

The output voltage wave is illustrated in Fig. 3. It will be noted that the peak voltage occurs when the coil is at point *A*, *C*, and *E* where the flux change is most rapid. At points *B* and *D*, where the flux change is nil, the voltage is zero.

The principles just outlined were first used by Valdemar Poulsen about forty-five years ago. To magnetize a steel wire longitudinally, he used a pair of electromagnets arranged as in Fig. 4A. While this system worked fairly well, the magnets affected a rather long section of the wire, and necessitated a high wire speed. This may be clarified by the following practical example:

Suppose that it were desired to record a 5000 cycle wave ($f = 5000$) on the wire, and the pole pieces were spaced $\frac{1}{16}$ inch ($\lambda = \frac{1}{16}$). Then the speed corresponding to wavelength of this size would be:

$V = f\lambda = 5000 \times \frac{1}{16} = 312$ in. per sec.

For good waveform the speed might have to be several times this figure.

Obviously, the mechanical problems of handling wire at such high speed were serious. Poulsen's device was bulky and noisy. The wire broke frequently, and pole-pieces wore so rapidly that they had to be renewed like phonograph needles.

Later experiments tried various methods of decreasing the pole-piece spacing. When the pole-pieces are opposite one another, the limit of decreasing pole-piece spacing is reached, as shown in Fig. 4B. This system is unsuited for use with round wire, because the wire might rotate about its axis between the time a record was made and the time it was played, thus causing objectionable variations in amplitude.

In an attempt to correct the difficulties previously encountered in magnetic recording, experiments at the *Armour Research Foundation* were directed toward a new type of recording head illustrated in Fig. 6. With this new unit, the recording was done in a small air gap, instead of by the use of sharpened pole-pieces. This air gap was made as short as 0.001 inch, so that only a very small portion of the wire was affected at one time.

Point *P* on the wire is moving in the direction indicated in Fig. 6B. When this point is at *A*, in the interior of the pole-piece, the magnetizing force acting on it is practically zero. As soon as it passes into the air gap *B*, it is magnetized by a concentrated field set up by the coil. As the wire continues moving, point *P* passes into the field-free interior of the second pole-piece

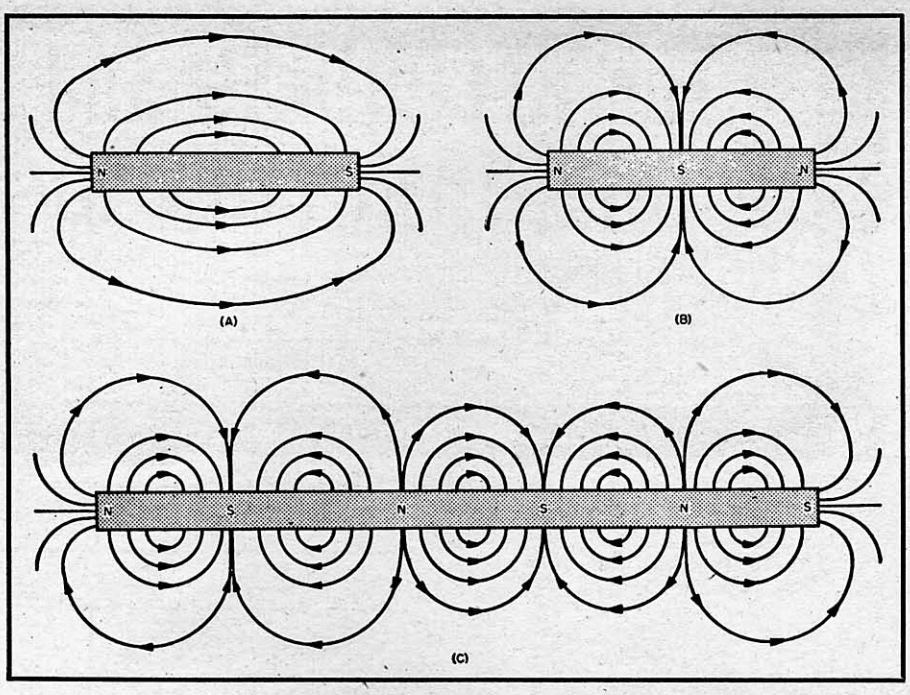


Fig. 1. Methods of magnetizing steel bars. (A) Dipole magnetized; (B) tripole magnetized; and (C) multipole magnetized steel bar.

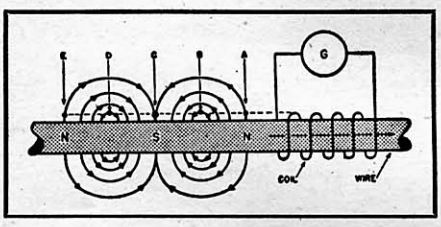


Fig. 2. How variations of magnetic field intensity are converted to an a.c. voltage.

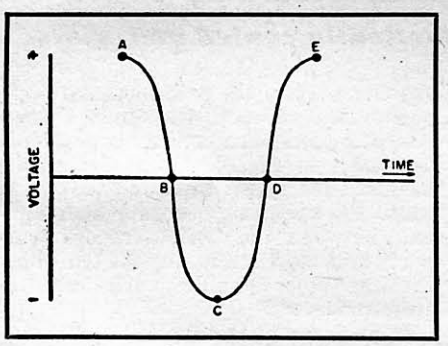


Fig. 3. Waveform (output voltage) on recording head when wire is magnetized as in Fig. 2. Peak voltage occurs when coil is at points A, C, and E. At B and D where there is no flux change, voltage is zero.

C. The ratio of the magnetizing force in the gap to that in the poles, may be estimated from the equation:

$$H = \frac{\mu}{B}$$

where:

H is the magnetizing force.
B is the flux density.
μ is the permeability.

Assuming that the flux density B is constant throughout the magnetic circuit, then the magnetizing force varies inversely as the permeability. Since the permeability of the pole-pieces is about 1000 times as great as that of the gap, the magnetizing force inside is only $\frac{1}{1000}$ that of the gap.

The magnet illustrated in Fig. 6A is used also for pickup of the recording from a magnetized wire. Analysis shows that the voltage picked up from the wire can be given by the expression:

$$E = B_m V \sin \frac{\pi W}{\lambda}$$

where:

E is the relative induced voltage.
B_m is the maximum flux density in the wire.
V is the velocity of wire travel.
W is the width of the air gap.
λ is the recorded wavelength.

The frequency response curve calculated from this formula is plotted as curve No. 1 in Fig. 5. Fixed values of $B_m V$, and W, have been chosen in this case. It will be noted that at frequencies low enough so that $\sin \pi W/\lambda$ is practically the same as $\pi W/\lambda$, the output voltage decreases at the same rate as the frequency. This limits the low frequency response.

High frequency response is limited by length of the recording gap, and also by the demagnetizing effect of adjacent magnetic poles at short wavelengths. The frequency characteristic can be made fairly flat by the use of a corrective network, as shown in curve No. 2 in Fig 5.[1]

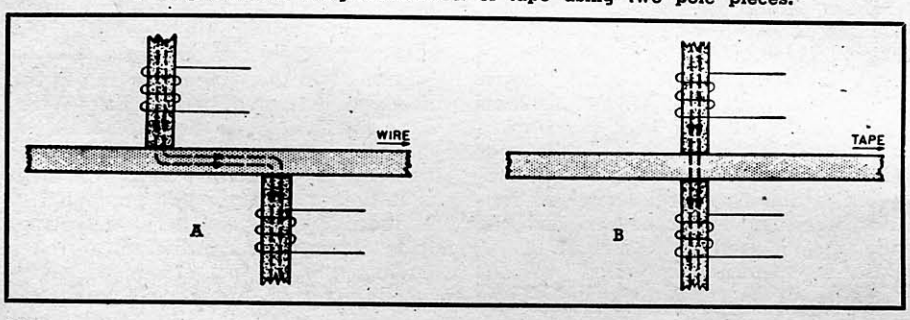
Generally speaking, magnetic recording machines are not particularly complicated. A magnetic material, such as wire or tape, is drawn past a recording head. As it passes through the head, the material becomes and remains magnetized. The amount of magnetization remaining in the material at each instant is governed by the impressed signal upon the recording head. In playing back, the magnetized material is drawn past a playback head. The varying magnetization which remains in the material induces corresponding voltages in the coil of the playback head. In modern practice the recording and playback heads are incorporated into a single unit.

The erasing of a signal from a magnetic material is accomplished by means of an erase head. This head impresses a field upon the material, which, erasing the old signal, makes the material ready to receive another signal or to be re-recorded. Basic components of magnetic recorders include the magnetic material, the record-reproduce head, and the erase head. In addition are the other component parts such as the drive mechanism, the spools or containers for the wire or tape, a compensated record and playback amplifier, conventional microphone, speaker, and special filter systems to overcome the nonlinearity of the magnetization curve of the recorded material.

It was discovered, following initial experiments with wire recording, that the application of a supersonic signal to the recording head was necessary to provide a bias to overcome the nonlinearity of the normal magnetization curve of a magnetic material.

Fig. 7 is a block diagram of a typical magnetic recorder. It will be noted that in the "record" position, the supersonic oscillator serves double duty by providing high frequency for both the demagnetizing head and the recording head. First the magnetic material passes through the erase head. The material is demagnetized

Fig. 4. (A) Longitudinal magnetization of wire using two pole pieces. (B) Perpendicular magnetization of tape using two pole pieces.



[1] Camras, Marvin, Armour Research Foundation, "A New Magnetic Wire Recorder" Radio-Electronic Engineering Edition of Radio News, November, 1943.

and is ready to receive a signal from the recording head. The application of a supersonic signal to the recording head provides a bias, as mentioned previously, and helps to overcome the nonlinearity of the normal magnetization curve of the magnetic material.

Magnetic Materials

We will avoid the term wire recorder wherever possible inasmuch as magnetic recording techniques apply equally to other materials such as paper tape and paper discs to which has been added a coating of magnetic material. In addition, certain alloys have been found which give excellent results in magnetic recording.

Recording Bias

Either d.c. or a.c. bias will improve the linearity of the magnetic material magnetization curve, as previously mentioned. The following will explore the advantages and disadvantages of each.

Referring to Fig. 8 we see the magnetization characteristics of a typical magnetic material. Beginning at point *A*, with the material demagnetized, the magnetizing force *(H)* is increased to point *B* and then reduced to zero. The material, however, has become permanently magnetized and the flux density *(B)* does not return to zero but instead only drops to a value of *C*.

If the magnetizing force had been increased to point *D* and then reduced to zero, the residual flux density would now correspond to *E*. Note that *(B)*, the residual flux density is not proportional to *(H)*, the field intensity. This is a source of nonlinearity better illustrated in Fig. 9 where the residual flux density is plotted against original magnetizing force. From the origin to point *X* the characteristic is very nonlinear. Between points *X* and *Y* the linearity is excellent while after *Y* it again becomes nonlinear. Obviously, for good reproduction some biasing is necessary to enable operation on the linear section between *X* and *Y*. Two systems—one using d.c. and the other a supersonic bias, have been developed and are widely used.

The d.c. bias employs a saturation erase. The material in passing the erasing head is magnetized to point *D* (Fig. 8) and therefore will return to a residual flux density of *E*. (*D-E-M-N* is the hysteresis loop of the material.)

In order to operate on the linear portion of the loop to the left of *E* a fixed negative field, *F*, is applied to the material by the recording head. When the material leaves the recording head, the flux density decreases along a nearly straight line to *G*. Suppose a signal superimposed upon the fixed negative bias varied the field intensity between *H* and *J*. If the material leaves the influence of the recording head pole-pieces, when the field intensity is *J*, the flux density would proceed along the practically straight line to *K*. From *H* it would have gone to *I*. Within a limited range in the neighborhood of *F* the lines *H-I*, *F-G*, and *J-K* will be almost straight and parallel. This means that the induced reproducing voltages will be linearally related to the recording fields.

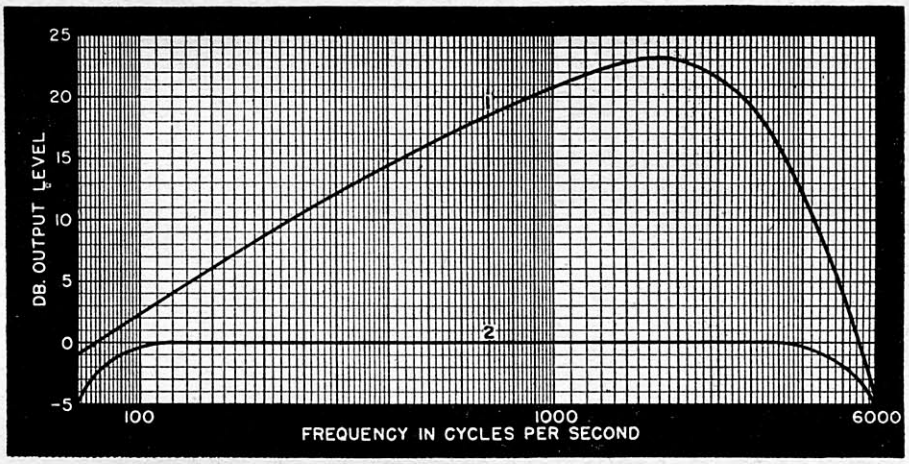


Fig. 5. Frequency response curves for wire recorder. Curve 1 shows output level minus corrective network. Curve 2 shows output with corrective network.

Of great importance is the magnitude of the fixed negative bias employed. If this bias is too small, the signal will be distorted by the nonlinear section near *E*. Too large a bias will cause signal distortion by carrying over into the section near *M*. There is a limit to the magnitude of the recording audio field, for the curve is linear only in a limited region around *F*. In addition, too large a field will produce distortion. We have ignored the self-demagnetization effects of thin sections of material such as are used in magnetic recording. Demagnetization will tend to further reduce the amplitude of linear recording when d.c. bias is employed.

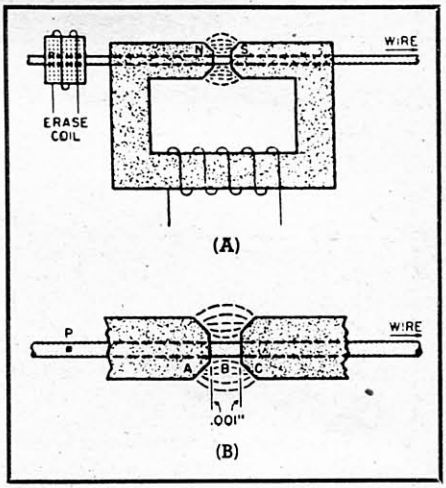


Fig. 6. (A) Cross sectional view of magnetic wire recording head. (B) Drawing illustrates details of the recorder pole pieces.

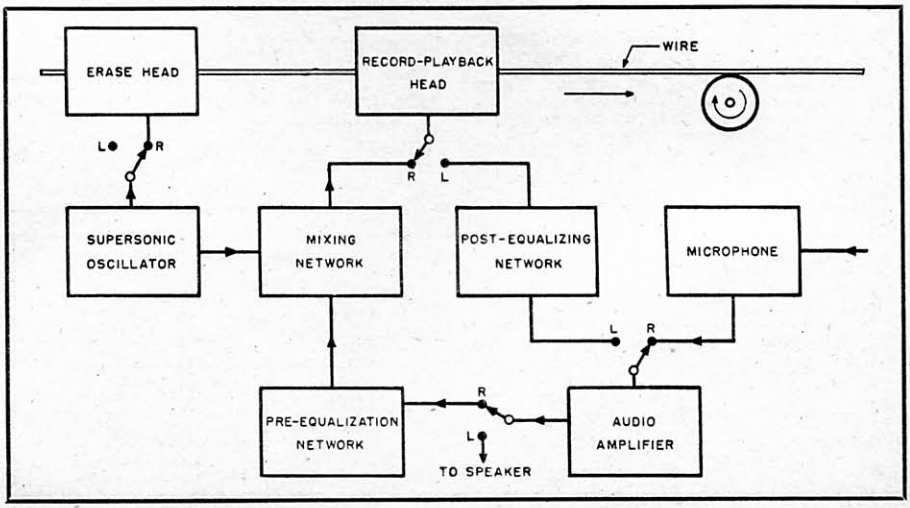
Supersonic Biasing

To overcome the nonlinearity of the magnetization curve, supersonic biasing was developed. It possesses several advantages over d.c. bias. Supersonic biasing, as its name implies makes use of a supersonic signal (30 kc. is commonly used) as a bias upon which the audio signal is superimposed. Normally the supersonic oscillator is also used for the erasing head, so that the magnetic material enters the recording head completely demagnetized.

Fig. 10 illustrates the action of supersonic biasing. Here a field which is a mixture of the supersonic bias and an audio signal is shown applied to the residual flux density curve. Let us

(*Continued on page* 142)

Fig. 7. Simplified block diagram of a typical wire recorder.



ANNOUNCING—

The first volume in the long-awaited Massachusetts Institute of Technology Radiation Laboratory Series, bringing you—

the engineering data you need to design RADAR SYSTEMS



Just Out

Here is an important book which presents the general principles of the design of various radar systems. From the standpoint of the designer the book discusses the basic considerations which underlie systems design.

RADAR SYSTEM ENGINEERING

Edited by Louis N. Ridenour, Editor-in-Chief, Radiation Laboratory Series; Professor of Physics, University of Pennsylvania. Over 900 pages, 6 x 9, $7.50.

AFTER a general approach to problems encountered, this authoritative book takes up the leading design considerations for the important components that make up a radar set. Detailed examples of actual systems are included. Two new and important auxiliary techniques —moving target indication and the transmission of radar displays to a remote indicator by radio means—are fully treated. Anyone interested in the varied applications of radar will find this new volume of immense value as a basic, useful reference.

10 DAYS' FREE EXAMINATION — MAIL COUPON

McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 18, N. Y.

Send me M.I.T. Radiation Lab. Series, #4, Ridenour RADAR SYSTEM ENGINEERING for 10 days' examination on approval. In 10 days I will send you $7.50 plus few cents postage or return book postpaid. (We pay postage cash orders; same return privilege.)

Name .....

Address .....

City and State .....

Company .....

Position RN-8-47

LEARN ELECTRICITY OR RADIO



. . in the

GREAT SHOPS OF COYNE

Train in a Few Short Weeks

Here at **Coyne** in a few short weeks you can train for your big opportunity in Electricity or Radio. You train on actual full-size Electrical or Radio equipment. 48 years training experience. **For Veterans and non-veterans.**

NOT A "HOME-STUDY" COURSE

All **Coyne** training is given here in our big Chicago shops. Not a Correspondence course.

VETERANS! **Coyne** is authorized to train Veterans under the G.I. Bill. Coupon brings details.

FREE BOOK Two great opportunity fields —rush coupon for free illustrated book on whichever course you prefer—no obligation. Tells how **Coyne** helps you get better jobs.

Your Choice of 2 Great Fields

B. W. COOKE, Dir., COYNE ELECTRICAL SCHOOL, Dept. C7-81H 500 S. Paulina St., Chicago 12, Ill.

Send FREE BOOK and full details on course checked:

☐ ELECTRICITY ☐ RADIO

NAME.....

ADDRESS.....

CITY.....STATE.....

first consider the magnetizing action of a typical wire record-reproduce head as illustrated in Fig. 11A. The demagnetized wire entering the head from the left will be shielded from the magnetic field until it enters the recording gap between the two pole pieces.

During the time in which it travels from the first pole to the shielding of the second pole, the element of wire will be subjected to the varying magnetic fields existing in the gap. In this time interval the audio signal intensity will have changed only a small increment. However, the supersonic bias will have gone through 1½ or 2 cycles. The residual flux density that is left in an element of wire will depend upon the field intensity existing in the gap at the instant that the element left the gap and entered the second pole. Referring again to Fig. 10, this means that if one element of wire had a residual flux density corresponding to a field of point *E*, the residual flux of the following segment would correspond to point *F*.

But what effect does this have upon reproduction? We find that the gap is long enough to contain several negative and positive peaks of the supersonic bias. The total flux in the gap will then depend upon the sum of the gap fluxes. In Fig. 10 the projection of the positive peaks on the residual flux curve at each instant of the audio signal produces curve *A*. The projection of the negative peaks forms curve *B*. The addition of *A* and *B* results in a curve that represents the effective flux that the wire will reproduce in the gap. Although some distortion is present in the resultant curve, it is a great improvement over reproduction without bias. As in d.c. biasing, the linearity of the response using supersonic

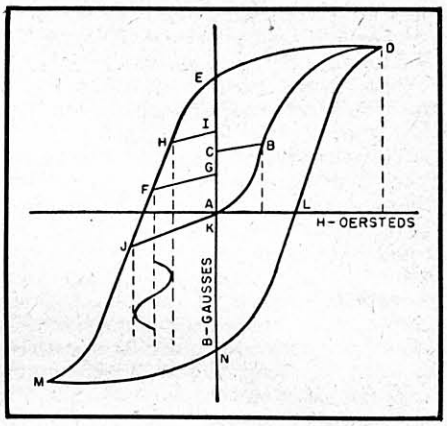


Fig. 8. Typical magnetic material magnetization characteristics.

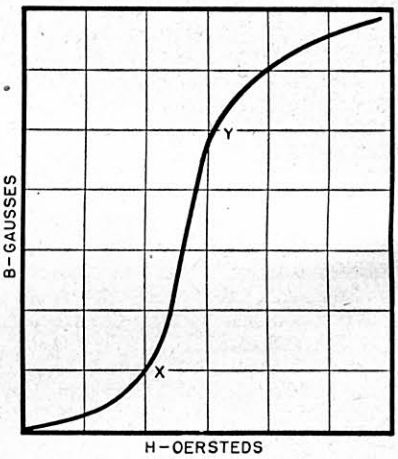


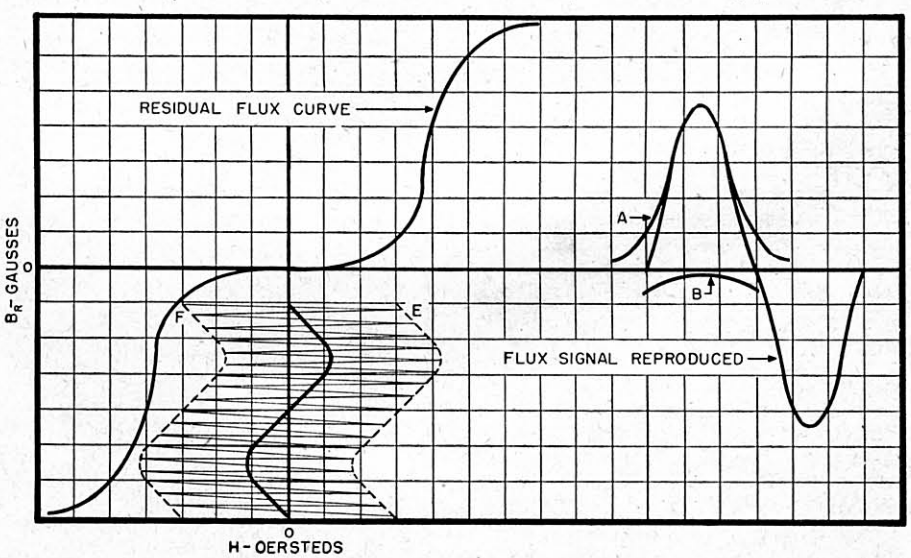
Fig. 9. Residual flux density curve.

biasing is dependent upon the amount of bias used. The response shown in Fig. 10 probably could be improved upon with a more careful choice of bias.

Distortion

Regular intermodulation measurements can be made to check distortion

Fig. 10. Supersonic biasing effect. Combined audio and supersonic magnetizing field is applied to residual flux density curve to plot the flux signal that the wire will produce in the gap.



and, accordingly, to check the bias for best results. A low frequency sine wave of fairly large amplitude is simultaneously recorded on the magnetic material with a high frequency sine wave of low amplitude. If the system were perfectly linear, the output of the reproducing head would show no modulation of the high frequency signal by the lower. As the system is not perfectly linear, some modulation will occur. The bias can be adjusted to make this a minimum.

Two advantages can be attributed to supersonic biasing as compared to d.c. biasing. These are, less noise and a greater linear amplitude range allowing higher level recording. Experimenters have been led to the conclusion that noise in magnetic recording is largely caused by the passage between pole pieces of many randomly distributed magnetic irregularities which are less than .0015 inch in diameter. Magnetically saturated material was found to be ten to twenty decibels noisier than demagnetized material. This means that d.c. biasing, with its saturation erase and fixed magnetic bias, will be noisier than supersonic biasing which uses a demagnetizing erase.

Magnetic Head Design

Fig. 12 illustrates in simplified form, various types of recording-producing heads now being commonly used. Practical experience has shown the desirability of combining the recording and reproducing functions into a single head. At the same time, while the overall response characteristics are influenced to some extent by the recording head design, they are much more dependent upon the design of the playback head. Therefore, the playback requirements usually govern the design of the head.

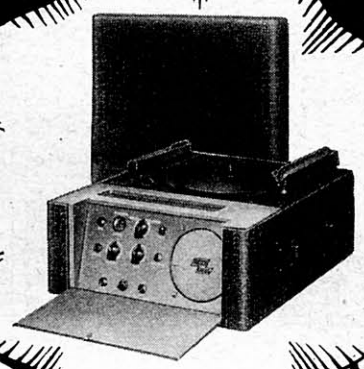
The open type head, commonly employed where a magnetic material is in the form of wire, is shown in Fig. 11B. Note that the wire hole of Fig. 11A has been replaced by a tapered slot. This is done for ease in placing the wire in the head while the taper will allow a splice or knot to be made in the wire and yet permit the wire to ride up out of the slot and prevent a jam. Fig. 12C shows a closed type head which is similar to the open type except that the coil surrounds both the wire and the pole pieces. The closed type reduces the effect of stray fields and produces a response curve that is a little more regular than that of the open type.

The heads illustrated in Figs. 12C and 11B may be made of several laminations if a high impedance head is desired, or of a single lamination if a low impedance head is preferred. In either case, the lamination should be kept as thin as practical to reduce eddy current losses and to improve the high frequency response.

Heads for record-playback should be made of a material that offers high permeability at low flux density. Mu metal or molybdenum *Permalloy* are commonly used. Magnetic coupling

Another MASCO PRIZE WINNING PACKAGE OF PROFIT

Dual Speed PORTABLE DISC RECORDER With Single Play-Back



NEW! With Every Facility of the Professional Type Recorder

Sensation of the Chicago Show... because distributors and dealers recognized the big market for this disc recorder and play back...broadcast stations, talent agents, schools, churches, lecture halls, night clubs and people who entertain at home.

It has 3 separate input jacks, providing for **1.** direct recording from microphone, **2.** direct recording electronically from a phonograph (dubbing), **3.** direct recording from radio to record. Selector switch on panel allows for simple change of function.

Volume level indicator eye assures accurate recording level. Separate volume and tone controls allow for any desired volume or tone setting.

Complete with heavy duty 6 in. P.M. Alnico V Speaker and kit of 5 matched tubes

List Price **$135.00**

Add 5% West of Rockies

Contact your local Masco distributor for immediate delivery. For descriptive literature or other information write directly to factory, Dept. N.

COMPLETE SELF-CONTAINED DUAL SPEED DISC RECORDER...

...AND PLAY-BACK WITH BUILT-IN AMPLIFIER AND SPEAKER

FEATURES

- Combined recorder and P.A. system.
- Recording and play-back both 78 and 33⅓ RPM.
- Electronic volume level indicator.
- Heavy duty 6 in. Alnico V Speaker.
- Separate volume and tone controls.
- Five tubes including rectifier.
- Separate jack for external speaker.
- Adjustable cutting head.
- Separate motor switch.
- Fused circuit.

MASCO

MARK SIMPSON MANUFACTURING CO., Inc.

32-28 49th Street, Long Island City 3, N.Y.

SOUND SYSTEMS and Accessories

RAvenswood 8-5810-I-2-3-4

F.M. KIT (88 to 108 MC)

Consists of Variable Condenser, Set of Matched Coils, Schematic and Instructions for building a Tuner **$4.95**

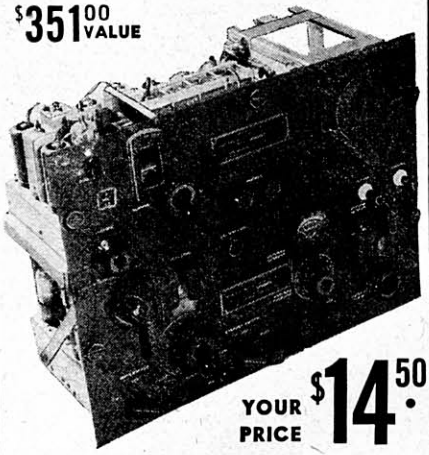
ELECTRIC PHONO MOTOR, complete with turntable	$ 2.95
CRYSTAL PICK-UP ARM	1.75
CRYSTAL CARTRIDGE	1.25
LOOP ANTENNA, assorted sizes, oval shape	.39
RESISTANCE CORDS, 160 to 290 ohms	.49
OSCILLATOR COIL, 456KC	.19
I.F. COIL, 456 KC	.59
SELENIUM RECTIFIER, 150 MA	.95
BROOKS INVERTER, 50 Watts—110 V (Also available in 220 V)	8.95
VOLUME CONTROL, any size with switch	.39
VOLUME CONTROL, any size less switch	.19
ELECTROLYTIC CONDENSER, P-B, 20/20—150 V	.26
ELECTROLYTIC CONDENSER, C-D, 40/40/20—150 V 25 V	.44
1000—ASSORTED TUBULAR CONDENSERS, .002 to .1	39.50
1000—ASSORTED RESISTORS, ½ Watt	15.00

BROOKS RADIO DISTRIBUTING CORP.

80 Vesey Street (Dept. B) New York 7, N. Y. CO 7-2312

RECEIVER EXMITTER

$351.00 VALUE



YOUR PRICE $14.50

FREE A COMPLETE SET OF TRANSMITTING AND RECEIVER TUBES WORTH $35.00

FREE 1-200 KC CRYSTAL

BC-654-A is a combined transmitter and receiver designed for portable or vehicular operation. The frequency range of both transmitter and receiver is continuous from 3700 to 5800 kilocycles; all stages gang tuned by anti-back lash worm gear dial mechanisms.

YOUR GUARANTEE

We will ship you at once the above receiver and exmitter and include FREE a complete set of 13 exmitter and receiver tubes.

— RUSH YOUR ORDER —

$5.00 Deposit—Balance Express Collect

MANUEL KLEIN

74R Cortlandt St., New York 7, N. Y.

Complete

TELEVISION COIL KIT

With these Coils, Construction of Your Television Set is Simplified

Instruction Manual for 20 Tube, 7 inch Picture Tube Set, included with each Kit.

Build a Quality Set with our 6 Channel Tuner; 5 stages, 4.25 MC Video bandwidth, IF Coils; and FM Sound-Discriminator, at Low Cost. Video Bandwidth satisfactory for ANY size Picture Tube.

OUR $23.50 OFFER

INCLUDES THE FOLLOWING

1 Oscillator Tank Coil, 1 Antenna Coil, 6 RF Tuning Coils, all mounted on Switch Assembly Plate; 5 Video IF Coils, Shielded, Permeability Tuned; 1 Shielded Discriminator Coil; 3 Video Peaking Coils, and Instruction Manual containing Circuit Diagram for 20 Tube Seven Inch Picture Tube Set, together with detailed Assembly Instructions, and Parts list.

ORDER DIRECT OR THRU LOCAL DEALER

TERMS

Shipped Parcel Post Prepaid on receipt of check or money order. Or P. P. collect on receipt of 25% deposit with order, balance C. O. D.
Manual only, $1.00 plus 12c postage. Television Parts, Deflection Components, C. R. Tubes, in stock. Send for free listing to Dept. J.

RAY-LECTRON CO.

706 Tenth Avenue
BELMAR, N. J.

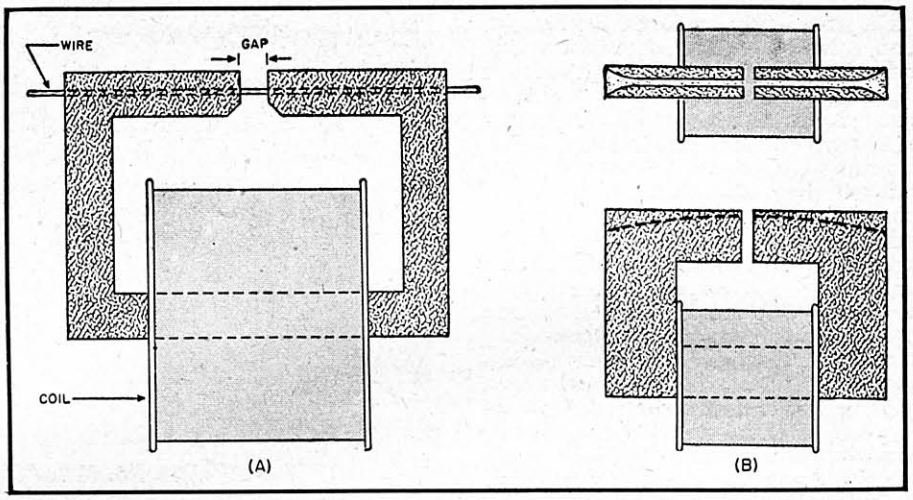


Fig. 11. (A) Typical wire record-reproduce head. (B) Open type wire record-reproduce head.

between the magnetic recording material and the head should be excellent. The gap between pole pieces is normally filled with a nonmagnetic material such as solder or soft copper but these materials wear excessively. Better results can be achieved and a more permanent head secured by employing beryllium copper.

The gap in commercial heads is usually somewhere between .001 inch and .002 inch depending upon the wire speed and the desired frequency response. Inasmuch as frequency range is largely dependent upon the length of gap, the matter of spacing becomes extremely important, as will be discussed later. The major difference between a recording-reproducing head and the erasing head is in the length of the gap. Usually an erasing head gap will be about .010 inch.

Considerations for Magnetic Tape Recording

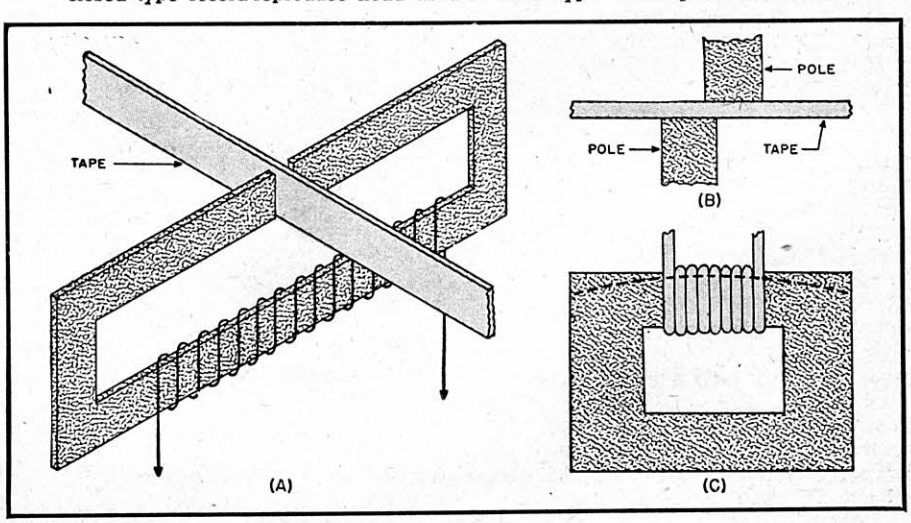
Considerable advancement has been made in magnetic recorders which employ a magnetized material in the form of a tape. As tape will run flat and will not twist when unwinding, it can be magnetized either longitudinally or transversely. A simplified diagram of a head for transverse recording on magnetic tape is illustrated in Fig. 12A. It will be noted that pole pieces are thin, single laminations. Increasing the thickness of the laminations will have the same limiting effect on frequency as increasing the gap on the head of Fig. 11A. Improved and increased response, combined with a sturdier construction is obtained by using thicker offset pole pieces (Fig. 12B). This head derives increased gain from the decrease in reluctance that wider pole pieces effect in the region of low permeability that exists at the end of each pole.

Frequency Response

As mentioned previously, the length of the air gap becomes a most important factor in setting the general frequency response of the system. The over-all frequency response of a magnetic recorder is also dependent upon such factors as head design, wire or tape speed, magnetic recording material, and amplifier compensation. Some of the frequency limiting factors in the recording-reproducing head have already been discussed.

If a wire containing two alternating magnetic fields, both of the same mag-

Fig. 12. (A) Record-reproduce head for transverse recording on tape. (B) Offset thick pole pieces used to improve characteristics of head shown in (A). (C) The closed type record-reproduce head used in some types of magnetic recorders.



EXCEPTIONAL ➔VALUES←

Complete stocks! Immediate delivery! Standard, nationally known and guaranteed merchandise at LOWEST current prices. Look at these challenging values—just a few we offer you. Send your trial order—learn more about our service. Prices shown, FOB Philadelphia. Terms 25% with order, balance COD.

TRANSVISION TELEVISION
Complete Kit and Cabinet



Famous for large, bright pictures of amazing clearness, excellent sound performance and high signal sensitivity. EASY to build without previous experience. No instruments to buy. Our price INCLUDES handsome walnut finish cabinet, speaker, all tubes, plus antenna. Nothing else to buy. REQUIRES NO ALIGNMENT. Price only..... $188.45

ATR "A" BATTERY ELIMINATORS FOR AUTO RADIOS



Type 60 Ella. Rated output 6.3 volts at 6.5 amperes. Has an on-off switch, pilot light indicator, 10 ampere fuse, rubber mounting feet. Heavy gauge metal cabinet. Operates at top efficiency. Delivers filtered current at correct voltage. Fully automatic and foolproof. Actual $34.95 value. Our price only..... $20.59

NATIONALLY KNOWN "UTILIPHONE" INTERCOM SETS $29.95



Famous for newest electronic designing, sturdy construction and quality parts. Smartly styled. High amplification invite, natural talking without leaning over close to speaker. Easy to install. An outstanding value. Our attractive price includes speaker and microphones. As low as only $29.95. Ask for Dealer Price.

GET THESE HI-VALUE SPECIALS

Phonograph Amplifiers	$3.75
Pick-Up Arm	2.10
Phonograph Motor	3.60
Top Cowl Auto Radio Antenna	7.36
80 Watt Solder Iron	1.69
100 Watt Solder Iron	2.29

A. C. RADIO SUPPLY CO.
1539 W. Passyunk Ave., Phila. 45, Pa.

WAR SURPLUS!

All merchandise is the product of nationally known manufacturers under government contract—no "off" brands.

Oscilloscope, Dumont 164E	$49.50
.1 mfd. 200 vwdc, paper condenser, Micamold	.05
In lots of 50, each	.04
4 mfd, 500 vwdc, paper condenser, for replacing electrolytics and give superior service	69
In lots of 50, each	.59
Cathode-Ray Power Xformer, Thordarson T-46543, 1250v, 880v CT, 2.5v, 2.5v, 6.3v, 6.3v, 5v	8.50
0-1 ma DC Meter, Weston 301, 3½"	4.25
5CP1 Cathode-Ray tube	4.83
100TH Transmitting tube	7.75
807 Transmitting tube	.95
¼ W Neon bulbs, candelabra screw or bayonet (Specify)	.11
Headset, HS-30, miniature type	1.27
Octal Socket, steatite	.15
Carbon Resistors ½W & 1W, any resistance value—10% Discount in lots 100 (may be asstd.)	.02½
Kit of 100 Carbon Resistors, ½W & 1W, mixed values (all useful values) Special	1.83

We have thousands of choice items in our warehouses too numerous to mention. Let us know your requirements. Drop us a card to receive our regular bulletins and flyers.

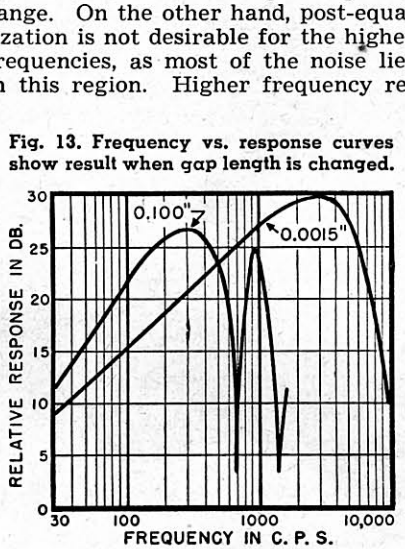
Price RADIO Laboratories
2816 Hemlock Ave., Baltimore 14, Md.
Minimum order $2.00. We also ship
C.O.D., 10% with order

nitude, but one twice the frequency of the other, is passed through a reproducing head, the higher frequency will induce an e.m.f. that is twice that induced by the lower frequency. This is, of course, caused by the fact that induced voltage is directly proportional to both the flux density and frequency. As might be expected, a constant rise in output is had with frequency but this is true only at the lower frequencies. At higher frequencies the response begins to drop off when the wavelength of the signal, as recorded on the medium, approaches the length of the gap. Fig. 13 illustrates the effect of gap length on frequency response while Fig. 14 gives the effect of wire speed.

The speed of the magnetic material has little effect upon the low frequencies but it does have a considerable effect upon the high frequency response. Commercial recorders operate at speeds ranging from 7.8 inches per second up to 6 feet per second with 2 feet per second giving excellent results on some of the latest models, such as the machine used to dictate this article. The current through the recording head coil determines the residual flux density which will be left in the magnetic material. A recording head is largely inductive and its impedance increases with frequency. It is necessary to use an amplifier with a rising characteristic to make the recording head current independent of the frequency of the input signal or to insert a large resistance in series with the coil. Constant recording current was used for the curves of Figs. 13 and 14. Referring to Fig. 13, it may be seen at a glance that some sort of equalization is required in order to achieve an over-all flat frequency response within the desired range.

Pre-equalization, post-equalization, or a combination of both are commonly used in magnetic recording. As the linear section of the magnetic materials magnetization curve does not extend indefinitely, only a limited amount of pre-equalization can be used before overloading. This is particularly true when using pre-equalization to extend the high frequency range. On the other hand, post-equalization is not desirable for the higher frequencies, as most of the noise lies in this region. Higher frequency response can be obtained by using pre-equalization but overloading necessitates reducing the recording level and lowering the signal-to-noise ratio as the range is extended. Inasmuch as the low frequency response is normally lower than that of the middle frequencies, some sort of equalization is required. Overloading precludes the supplying of all of the required equalization with pre-equalization alone. Therefore, a combination of pre-equalization and post-equalization will be found to be most satisfactory.

Fig. 13. Frequency vs. response curves show result when gap length is changed.



Materials for Magnetic Recording

Many varieties and shapes of magnetic materials are now being employed for magnetic recording. Noise level, frequency response, and signal amplitude will be affected by the type of magnetic material used. At the lower frequencies, with a fixed speed, the retentivity (measure of residual flux density) will determine the magnitude of output voltage from the reproducing head. However, we find that the shorter magnetic poles of the higher frequencies in the thin cross section of the magnetic material produce a strong self-demagnetizing effect which tends to reduce the induced higher frequency output voltage.

The effectiveness of this demagnetization depends upon the coercive force of the material. Coercive force is defined as the magnetizing force required to reduce the residual flux density to zero after saturation. If the residual flux were *N*, Fig. 8, the coercive force would be *AL*. Materials having a high coercive force will experience less self-demagnetization. Since high coercive force materials have a low retentivity, it means that some low frequency output voltage must be sacrificed in order to extend the upper frequency range.

High coercive force and low retentivity offer the additional advantage of reducing noise from crosstalk induced into the material by an adjacent turn of material when wound upon the spool.

Improved magnetic tape, having only part of its density occupied by the magnetic coating, does offer a certain amount of insulation and crosstalk is not encountered when turns are wound over one another on the spools.

There are two commonly used types of wire for magnetic recording. If we are satisfied to reproduce only the human voice, say to 3000 c.p.s., hard drawn carbon wire, or a chrome steel with a coercive force of about 50 oersteds is very satisfactory. Stainless steel wire possessing a coercive force of 175 oersteds will give recordings that are superior to the common shellac records found in our stores, but not quite equal to the latest vertically cut vinylite records.

When Vicalloy tape (developed by *Bell Telephone Laboratories)* with a coercive force of 250 oersteds is used, the quality of vertically cut vinylite can be readily equalled. An equalized response from 100 to 8000 cycles, with

a useful volume range of more than 50 decibels, has been obtained from Vicalloy tape using the recording-reproducing head illustrated in Fig. 12B. The tape speed in this case was only 16 inches per second. Considerable research on magnetic tape recording has also been done by the *Indiana Steel Products Company*. (Metallic wire and tape are the most common magnetic material shapes used in magnetic recording.) A German machine, on the other hand, was found that records upon magnetically coated plastic tape, producing forty-five minutes of recording from one-half mile of tape. It possesses the additional feature of a special pitch restoring head that permits restoration of the original pitch when the tape is played back at other than the recording speed.

Magnetically Coated Tape and Paper Discs

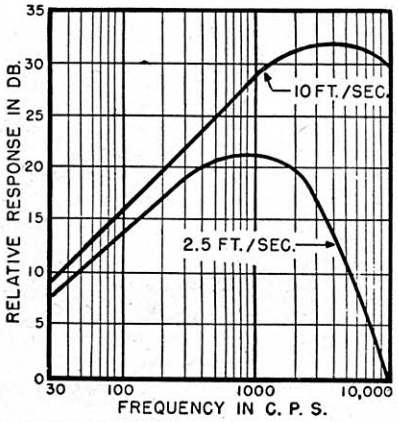
Considerable research has been done in the United States by the *Brush Development Company* on magnetic recording materials. Both a magnetically coated paper tape and a magnetically coated paper disc have been used successfully. Here the recording medium is a suspension of finely divided magnetic particles in a coating applied to paper. Paper tape is very easy to handle and cheaper than most other magnetic materials. It lends itself readily to editing for a section of the paper tape may be cut out with a scissors and the ends joined with glue or adhesive.

Plated brass wire has also been found to be well suited to magnetic recording. A frequency response of 80 to 8000 c.p.s. (down 6 db. at 10,000) with a signal-to-noise ratio of 35 db., can be obtained. The wire is .0046 inch in diameter and is plated with a magnetic material. Wire speed is 24 inches per second and the minimum recording time is four hours for a unit which has been developed.

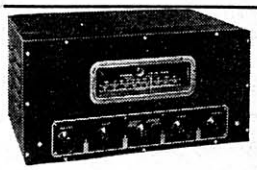
Another unit uses a ¼ inch wide magnetic coated paper tape. The frequency response is 100 to 5000 c.p.s. with a signal-to-noise ratio of at least 40 db. The tape speed is very low, being only 7.8 inches per second.

New uses are being found for magnetic recording almost daily. Expand-

Fig. 14. Illustrating the influence of wire speed on frequency response.



PARTS AND EQUIPMENT SPECIALS!



MEISSNER AM-FM TUNERS

Covers the FM band from 88 to 108 MC. At 105-125 volts, 50-60 cycles, power consumption is 80 watts. Tubes: 9003 R.F. amplifier; 6BE6 oscillator-converter; 2—9003 I.F. amplifiers (456 KC); 6AL5 detector for the AM section. For the FM Section: 6AG5 R.F. amplifier; 6C4 oscillator; 6AG5 converter; 3—6AG5 I.F. amplifiers (10.7 MC); 2—9001 limiters; and 6AL5 detector. Two 6C4's are used for audio amplifiers, a 6U5/6G5 for tuning indicator and 5Y3GT/G for rectifier.

Now Available for Immediate Delivery. Write for Prices.

BROWNING FM-AM TUNERS

Receives both old and new FM band (87 MC to 109 MC) and standard broadcast band (530 KC to 1650 KC). 115 volt 60 cycle operation. Tubes: one 6BE6, one 6C04, one 6BA6, one 6SG7, two 7AG7, two 6SJ7, one 6H6, one 6SA7, one 6SF7, one 6E5 or 6U5 (tuning eye).

Net Price $143.90
POWER PACK for above 15.73

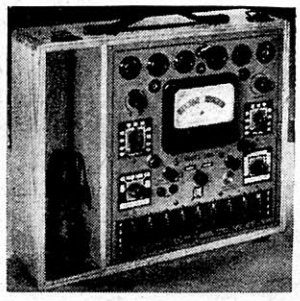


The MEISSNER RADIO-PHONO-RECORDER

Portable Radio, Recorder, and Public Address System. 7 tubes. High fidelity crystal-cutting head for 10" records. Excellent crystal microphone. Dual turntable speeds, 33⅓ and 78 r.p.m.

Now Available for Immediate Delivery. Write for Prices.

25% Deposit on All Orders



Electronic Measurements Corp.
SERIES 200

MUTUAL CONDUCTANCE TUBE CHECKER

Model 200 AC 3" meter in sloping counter case..... $49.85
Model 200 AP 3" Meter in hand rubbed carrying case .. $53.85
Model 200 BC 4½" Meter in sloping front counter case.... $52.85
Model 200 BP 4½" Meter in hand rubbed carrying case... $56.85

Here for the first time is a true mutual conductance type tube tester with complete flexibility, and at a price no higher than that charged by other manufacturers for the ordinary emission type.

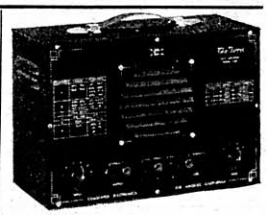
CHECK THESE FEATURES!

1. Checks mutual conductance on a calibrated microohm scale, as well as on a REJECT-GOOD scale.
2. Checks five element tubes as pentodes.
3. Checks tubes for gas content.
4. Detects both shorted and open elements.
5. Complete switching, flexibility allows all present and future tubes to be tested, regardless of location of elements on base.

GUARANTEED ELECTROLYTIC TUBULAR CONDENSERS

Sprague 16 MFD 450 v.....ea. 49c
Mallory 40x20 MFD 150 v.....ea. 49c
Solar .01 MFD 400 v.....per 100 $7.00
8 MFD 450 v.....10 or more, ea. 25c
20 MFD 150 v.....10 or more, ea. 26c





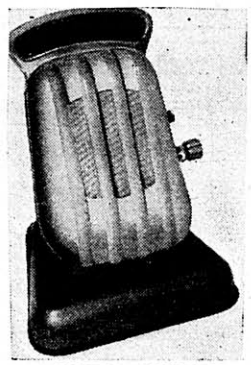
SOMETHING NEW IN TEST SPEAKERS

No need to carry the speaker to your shop in servicing any radio from the small midget to the most elaborate console. Any output tube or tubes can be matched simply by rotating input switch to tube listed on the front panel and rotate field switch for proper impedance and proceed with testing. External voice coil connection permits testing of set speaker to determine if output-transformer is open or shorted. Field Impedance: 500, 1000, 1500 and 2500 Ohms.

$19.95

OUTDOOR AERIAL KITS

Complete with 25 ft. lead-in wire, 50 ft. antenna wire, ground straps, glass insulators and nail knobs. Each..... **69c**



"ULTRA MIKE" WIRELESS MICROPHONE

This unit with your regular radio and NO extra interconnecting wires will provide superior results as a

- CALLING SYSTEM
- PUBLIC ADDRESS
- DETECTOPHONE
- BABY OR INVALID WATCHER

The "Ultra Mike" is light—economical to operate—completely self contained—no connections to power lines—portable.

Complete with batteries, tubes, etc.
YOUR COST..Special **$6.63**
Retail $18.00
F.O.B. Chicago

The Radio Shack Inc. OF CHICAGO

630 W. RANDOLPH STREET CHICAGO 6, ILL.

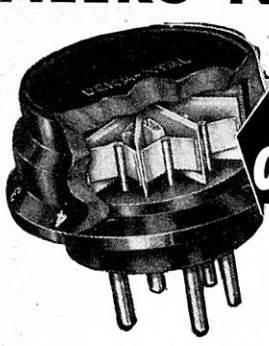
5,000 DEALERS NEEDED!

to sell this Popular Holder to Amateurs

DEKA XTAL

We need DEALERS to handle the demand created by national advertising for this unique Deka Xtal. Supply the amateurs in your territory. Write NOW for profitable dealer plan!

The Deka Xtal is rugged, compact, sealed against moisture and dirt. Plugs into oscillator for crystal control and signal shifting.



10 FREQUENCIES WITH FINGERTIP CONTROL

10 CRYSTALS

Deka Holder less crystals..... $5.95
Your choice of crystals in 40, 80 meter bands ± 1 KC. Ea. $1.35
20 meter band ± 4 Kc. Ea. $2.00

SPECIAL PRE-LOADED UNIT PRICE
Deka-Xtal and 10 crystals selected by Scientific to cover your favorite ham band..... **$14.95**

SCIENTIFIC RADIO PRODUCTS COMPANY
738½ W. Broadway, Council Bluffs, Iowa

Highbridge's Best Buy

BRAND NEW 7EP4

Immediate Delivery

Individually packed—in original cartons—Guaranteed..... **$19.50**

WESTERN ELECTRIC INPUT TRANSFORMER

Video core type; imped. ratio between windings: 1-2, 3-4, 5-6, in parallel 50-900 ohms; Freq. range, 10 KC to 2 MC; made for set AN/APQ-13; Electrostatic shield between windings, oil filled; 5¾" diameter, 5" high, wt. 5 lbs..... **$1.95**

KS-9524—Transformer Pri. 115 V—60 cycles. Sec. #1—450 V @ 30 MA C.T., Sec. #2-6.4 V. @ 1250MA. Rectangular metal case, stud. mtg. solder eyes—approx. size 3 1/16 x 2 5/16 x 3⅜ with stand-off 4⅜.

No. T2G-97. Special..... **$1.95**

I.R. #7313 Filament Trans. 115 V—50-60 cycle. Sec. #1—27.KV @ 4.3 amps No. C.T.:—Sec. #2—5.1 V @ 3 amp C.T.; Sec. #3-64 V. @ 3 amp No. C.T.:—Sec. #4 5.1 V. @ 3 amp C.T.:—Sec. #5—2.6 V. @ 3.5 amps No. C.T.:—Rectangular metal case, solder post terminals; Mtd on porcelain standoffs: stud mtg. size 5⅝ x 4¾ x 5⅜ with standoffs 6⅛.

T2E-88. Special **$4.95**

New 631 PI/SNA glass strobotron tube, ea. **$3.25**

100 By-Pass Condensers, 10 Varieties. Special..$4.95

High voltage transformer with Glass Standoffs. Pri. 115 V. A.C.—400 cycle—Sec. 5,700 V. Rectangular: approx. size 6⅛ x 4¼ x 3⅜ with standoff 7¼"—13 Mills D.C.

T3F-7. Special **$3.95**

TUBE

12A6	.83	6SN7	.79
6SQ7	.83	6517	.83
6AJ5	1.25	6C4	.79
1625	.70	5FB1	5.95

All Prices F.O.B. New York City, N. Y.

Highbridge Radio-Television and Appliance Co.

343 Canal CA 6-8661 New York 13

Don't forget to refer to the

RADIONIC Catalog!

... BECAUSE IT'S ONE COMPLETE COMPREHENSIVE RELIABLE VOLUME

PARTS AND ACCESSORIES • TEST INSTRUMENTS • RADIOS • TELEVISION COMPONENTS • INTERCOMMUNICATORS • RECORDERS • PUBLIC ADDRESS • TUBES • HARDWARE • RECORD CHANGERS • TECHNICAL BOOKS

CHANCELLOR RADIO

RADIONIC EQUIPMENT COMPANY

DEPT. 58 — TRIBUNE THEATRE ENTRANCE 170 NASSAU ST., N. Y. 7, N. Y. CABLE "CHANSLOR" — WOrth 2-0421

Radionic Equipment Co., Dept. 58
170 Nassau Street
New York 7, N. Y.

Please send me a FREE copy of your 1947 Catalog. I understand it has thousands of items illustrated, described and priced and will be a great help to me in my search for "hard-to-find" radio equipment, CHANCELLOR Portable and Phono Radios.

Name.....

Address.....

City.....State.....

MAIL TODAY

ing at a terrific rate and becoming more and more popular with the passing of time, magnetic recording bids fair to become universally used not only in certain dictating machines but also as a conventional entertainment media.

(To be continued)

Capacitance Test Bridge

(Continued from page 43)

critical nor will it affect the bridge circuit, but it should have as high an inductance as is possible. Its object is to prevent the bridge supply voltage from being shorted by the polarizing voltage power supply. The 3 μfd., 1000 v. condenser in series with it is to prevent any polarizing voltage supply ripple from reaching the input of the bridge.

The null indicator is a vacuum tube voltmeter circuit. The series grid resistance is to limit grid current flow, since the voltage applied to the input circuit of the 6SJ7 is rather high for conditions of unbalance. The 1 megohm grid resistance is to make the input resistance of the null indicator equal the bridge output impedance. The unbalanced bridge condition slightly lowers this input resistance (due to grid current) but as the balanced condition is approached, the input resistance becomes approximately that of the grid resistance. The tube is designed for maximum voltage gain and is followed by a 6H6 diode rectifier. The first portion of the 6H6 (on the drawing) serves to rapidly discharge the coupling condenser from the 6SJ7, and the second portion rectifies the output and applies it as bias through an *RC* filter to the grid of the 6SF5 . The plate resistance of the 6SF5 is so chosen with the voltage used, and the grid grounded, that the current in the plate circuit is limited to approximately 1 milliampere. Contact voltage of the 6H6 will cause this value to be lower since it is actually applied as bias, but this initial adjustment will protect the meter should the 6H6 burn out, etc. It will also be noticed that should the coupling condenser become shorted, the positive voltage will not be applied to the grid of the 6SF5, but rather be harmlessly bypassed through the first portion of the 6H6. The power supply transformer has a 650 volt, center-tapped winding.

The whole amplifier and power supply is above chassis ground to prevent shorting out one arm of the bridge circuit. The power transformer core and shell should also be insulated from the chassis since capacity indications of the bridge will be lower than the true value. It is much easier to do this than to compensate for its effects in the bridge circuit.

The principle of this arrangement is that when the bridge is unbalanced the condition is reflected into the grid circuit of the 6SJ7, its amplified output rectified by the 6H6 and applied as bias to the grid of the 6SF5, caus-

NEW LOW PRICE!

APPROVED Model A-200 **SIGNAL GENERATOR**



- 8 R.F. Bands—100 Kc.-75 Mc.
- External Modulation 20 to 30,000 cycles.
- Internal Modulation at 440 cycles.

Former Price—$49.50

For operation on 105-120 volts, 50/60 cycles A.C.

NOW *only* $39.50 You Save $10!

• Mail orders require 25% deposit, balance C.O.D. •

SCENIC RADIO & ELECTRONICS CO.

53 Park Place • Dept. R • New York 7, N. Y.

12 lbs. SURPLUS ELECTRONIC PARTS $2.00

A gold mine of parts for repairmen, amateurs, and experimenters . . . sockets, condensers, resistors, transformers, coils, hardware, wire, etc., etc. An outstanding bargain in usable parts! Send $2.00 cash, check or M.O. today! (Pay small express charges on receipt.)

ARMY SURPLUS TU-5-B TRANSMITTER-TUNING UNIT

Range 1500-3000 KC.

Individually cartoned. Component parts value many times this special price of.....**$2.39**

(F.O.B. CHICAGO)

ELECTRONIC DISTRIBUTORS, Inc.

Dept. A8 — 620 W. Randolph St. — Chicago 6, Ill.

ELECTRICAL TRAINING

Intensive 32 weeks' residence course in fundamentals of industrial electrical engineering, including radio, electronics. Prepares for technician, engineering aides. Approved for veteran training. 54th year. Catalog.

BLISS ELECTRICAL SCHOOL 7698 Takoma Ave. Washington 12, D. C.



NOW Sonnet FOR YOUR SILENT PROJECTOR *Economically*

$59.95

Convert your 16mm silent projector to sound (regardless of make) with Apex sound head & radiofilm adapter. Guaranteed excellent performance. Write today for free information.

APEX VIDEO • 12209 J Branford St. • Roscoe, Calif.

SENSATIONAL VALUES

3-TUBE HI-FI PHONO AMPLIFIER KIT: tubes, volume & tone controls, output trans. & 5" PM speaker	$6.95
Above Kit Assembled and Tested	9.95
HIGH GAIN CRYSTAL PICKUP	1.94
ALLIANCE PHONO MOTOR—9" TT	3.69
Portable Phono Case—for above kit	4.95
FILTER CONDENSER—8 mfd-450 v	.29
12A8-12K7-2525-35L6 and others	.59
MIDGET ANTENNA LOOPS	.39
AC RUBBER LAMP CORD—100 ft. for	188

REMER RADIO

5904 S. Princeton — Chicago 21, Ill.

MOTOR-GENERATORS

War Surplus machines built by Allis Chalmers Co. to U. S. Navy specifications. Brand new.
Input: 115 volts D.C. at 14 amps. 3600 rpm.
Output: 120 volts A.C., 60 cycles, single phase at 10.4 amps. One thousand watts continuous duty.
Ball bearings. Splashproof. Fully covered.
Centrifugal starter. Frequency adjustable to load.
Price f.o.b. Tuckahoe, N. Y. $87.50

ELECTRONICRAFT, INC.

Motor Div.

5 Waverly Place — Tuckahoe 7, New York

Radio Technician and Announcers

A practical fifteen-month course in First Class Radiotelephone Operation and Announcing is offered by Don Martin School of Radio Arts. Most stations these days require combination men. We specialize in this type of training and maintain a placement bureau for our graduates. Serving the Industry for ten years, the School of Radio Arts can train you. Write for our catalogue outlining the courses offered. Classes can be arranged so you can do part time work on the side.

APPROVED FOR VETERANS

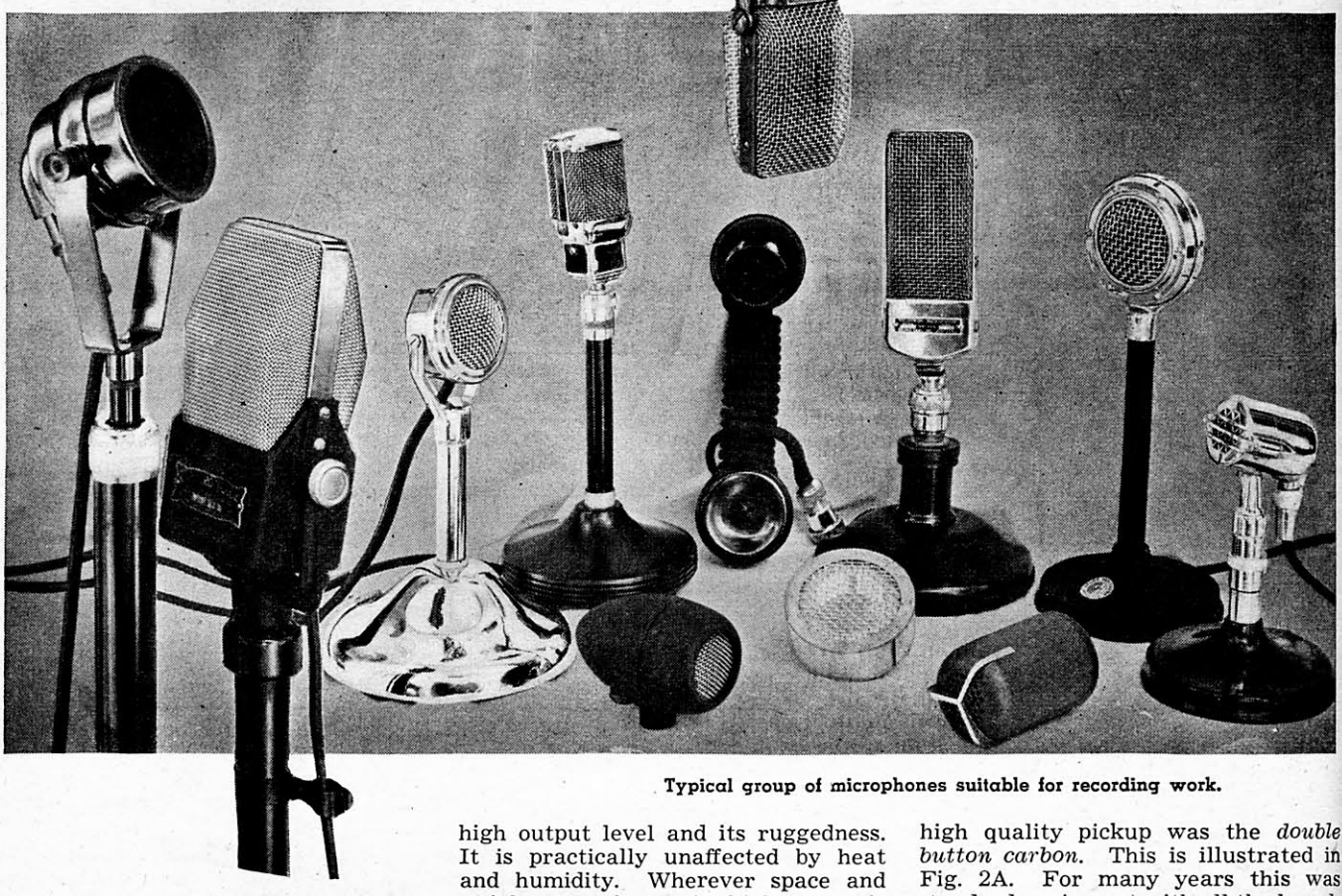
DON MARTIN SCHOOL OF RADIO ARTS

1655 North Cherokee St. — Hollywood 28, Calif.

The Recording and Reproduction of SOUND

Part 7. A discussion of representative microphones widely used in recording.

By
OLIVER READ
Editor, RADIO NEWS



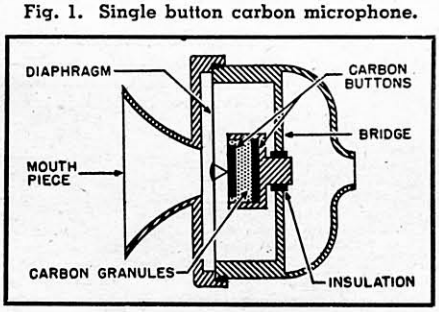
Typical group of microphones suitable for recording work.

THERE are three fundamental types of microphones (transducers). These are the carbon, crystal, and dynamic. Each type employs a specific fundamental principle of operation. While there are many variations on the above three types, we shall confine most of our discussion to the construction and application of those enjoying the greatest popularity.

A *carbon* microphone functions as follows: Direct current flows through the carbon granules. As the pressures and rarefactions of the sound waves occur at the diaphragm, the diaphragm is caused to move and to press and release the carbon granules. The action is decreasing and increasing resistance within the microphone. Accordingly, pulsating direct current results, the pulsating or alternating part having the same waveform as the original sound wave. The characteristic of the carbon microphone is its high output level and its ruggedness. It is practically unaffected by heat and humidity. Wherever space and weight are a factor, its high output is advantageous, due to the fact that one or two preamplifier stages may be eliminated. During the war this type of microphone was widely used by the military services. It is used presently by airline and railroad companies, police, etc. The construction of the single button carbon microphone is illustrated in Fig. 1.

In the early days of broadcasting the most commonly used microphone for high quality pickup was the *double button carbon*. This is illustrated in Fig. 2A. For many years this was standard equipment with all the broadcasters and, although it had its limitations, it proved very successful until replaced by the more popular velocity, dynamic, and other types. Carbon microphones, being of the pressure type, are largely used in mobile communications. They possess extremely good response at voice frequencies. The harmonic content of a single button microphone, due largely to the non-linearity of the carbon itself, is a source of at least 10% harmonic distortion even in the more advanced types. This, however, is no handicap when we limit the over-all response to voice frequencies. Generally speaking, carbon microphones are usually of 100 ohms impedance and are fed direct to a transformer or to a resistor input to the preamplifier.

Fig. 1. Single button carbon microphone.



Crystal Microphones

The *crystal* microphones, of which there are several types, employ bimorph Rochelle crystals. The

crystal element itself consists of two Rochelle salt slabs which are assembled in such a manner that they respond to a bending stress. The two slabs are provided with three foil electrodes so that the assembly is capable of generating a potential between the inner and outer foils whenever subjected to a strain or bending. Fig. 2B illustrates the construction of a diaphragm actuated crystal microphone. A drive pin is connected to one or two corners of the crystal and the other end of the drive pin is attached to a diaphragm. The movement of the diaphragm and drive pin bends the crystal in accordance with the pressure of the sound waves. This creates an alternating potential of substantially the same wave pattern as the sound wave. A crystal microphone does not require a separate voltage or current source, as is the case with the carbon microphones. The output of the microphone, accordingly, can be connected directly to the grid of an amplifier tube. The chief disadvantage of the crystal is that its operation is confined to temperatures of less than 130 degrees F. Temperatures over 130 degrees F. cause the crystal elements to soften due to excessive heat and the microphone is rendered inoperative.

The construction of the crystal microphone illustrated in Fig. 2B is the simplest form of crystal microphone. They are widely used for communications mikes and for the tiny hearing aid devices.

Sound Cell Microphones

A *sound cell* microphone consists of two bimorph crystal elements as illustrated in Fig. 2C. These elements are assembled back to back and are enclosed within a rectangular bakelite frame, sealed by two flexible membranes. The crystal elements are held together by two resilient mounting pads located in such a manner as to provide proper damping characteristics and to separate the elements, permitting them to deflect under application of sound pressures. No diaphragms are required in a sound cell microphone since sound pressures contact the crystal elements directly.

After assembly, the completed sound cell is impregnated with wax to render it airtight and moisture-proof. The result is a small, flat, hollow box, the two major sides of which generate a voltage in proportion to the applied pressure. For sound pressures, the voltage generated by one side will be in phase with that generated by the other and for this reason are additive. In the case of mechanical shock or vibration, the voltages will be out of phase and will tend to cancel each other. Due to the linear relationship between sound pressure and voltage, amplitude distortion does not arise as is the case with practically all other types of microphones. Crystal elements used in sound cells have been designed so that their mechanical resonances are usually above the highest frequency to be reproduced. In higher quality sound cell microphones, very small and very thin crystal elements are used, in which case the mechanical resonance is just above 10,000 c.p.s. causing the response to rise slightly at the upper frequency range. This increased output may be found useful in compensating for the high frequency loss in associated equipment, or it may easily be compensated for true equalization.

In some microphones single "sound cells" are used as illustrated in Fig. 2C. In others, double "sound cells" are used as illustrated in Fig. 2D. Usually a number of these are stacked together to provide proper operating characteristics. Sound cell microphones have been developed for various applications. They are ideally suited to high quality broadcasting, recording, audition and sound reinforcement applications. Generally, these are designed for connection to high impedance circuits but with special coupling transformers may be fed to low impedance lines. Each of these

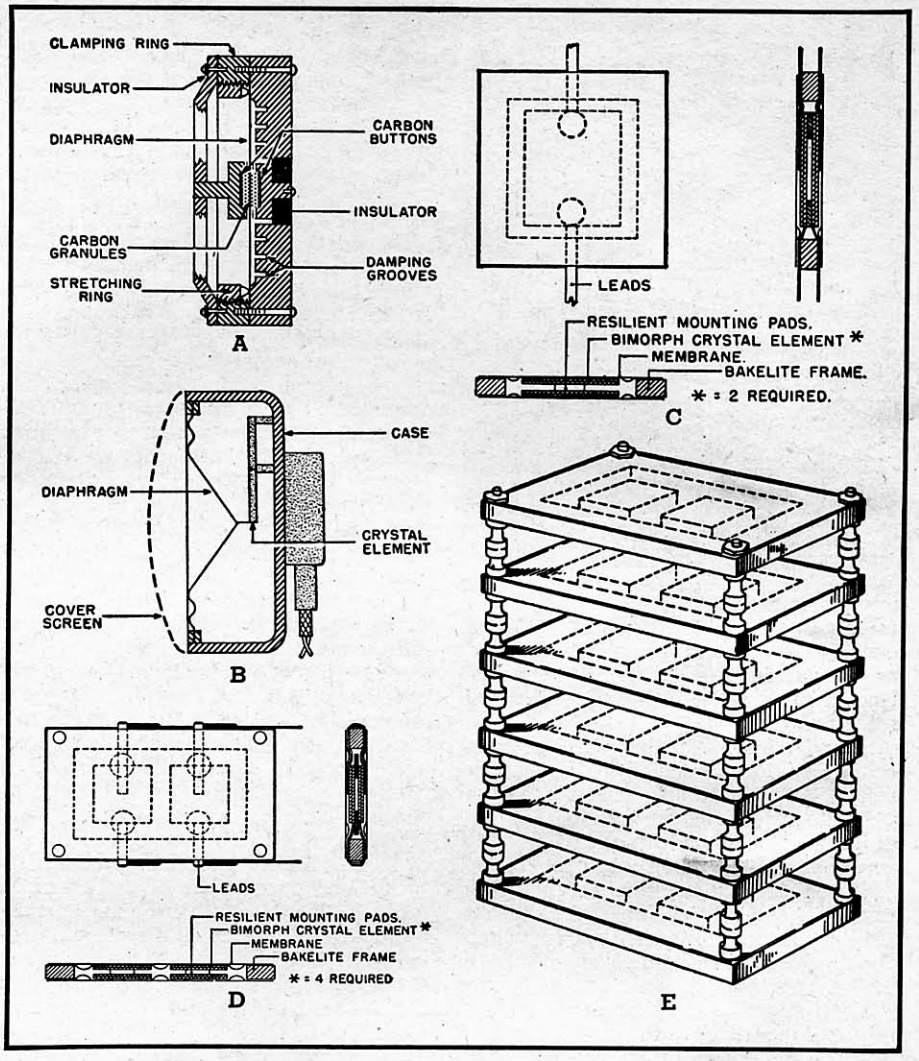


Fig. 2. (A) Double button carbon, (B) crystal diaphragm, (C) sound cell, (D) multiple sound cell and (E) six element sound cell construction.

Fig. 3. Input connections for sound cell microphones.

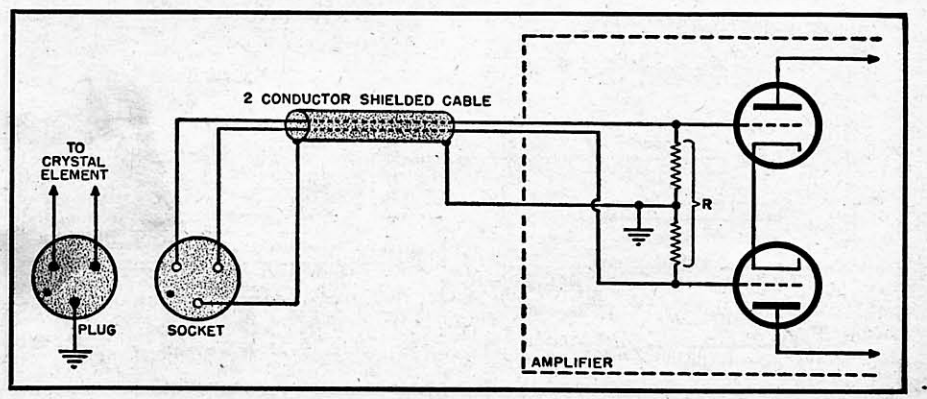




Fig. 4. Moving coil (dynamic) microphone.

microphones has a substantially uniform response up to 10,000 c.p.s. Each contains six double sound cells stacked as shown in Fig. 2E. The connections to the cells, however, differ for some models.

Sound cells have also been used in other devices such as laboratory microphones, artificial ears, etc. where very accurate measurements are required. For these applications the response is uniform up to 15,000 c.p.s. This is accomplished by using extremely small sized crystal elements (7/32 in. sq. x .015 in. thick) in which the mechanical resonance is well above 40,000 c.p.s.

Each sound cell microphone is terminated in a three point plug-in socket. Two of the contacts are connected to the output terminals of the sound cell assembly. The third contact is connected to the case of the microphone. This permits connection to single tube or push-pull grid inputs as shown in Fig. 3. Since the crystal elements of the microphone are capacitive over practically their entire frequency range, it is very important that each microphone be operated into the load impedance as recommended by the manufacturer. The capacity of the crystal elements will vary somewhat with temperature. However, this will have no effect on performance if recommended load impedances are used. Sound cell microphones should never be subjected to temperatures exceeding 125 degrees F. since the piezoelectric properties of the crystal elements may be damaged permanently.[1]

Non-directional Microphones

Pressure microphones respond to variations in sound pressure. They include dynamic, carbon, crystal, condenser, and ribbon microphones with closed backs. These are substantially non-directional although they tend to become directional at the higher frequencies. For a microphone of 2½" diameter, directivity starts at about 2000 c.p.s. and increases with frequency. Often baffles are used to lower the frequency at which directivity begins. But, as these add some frequency distortion, the design of the microphone must be coordinated with them.

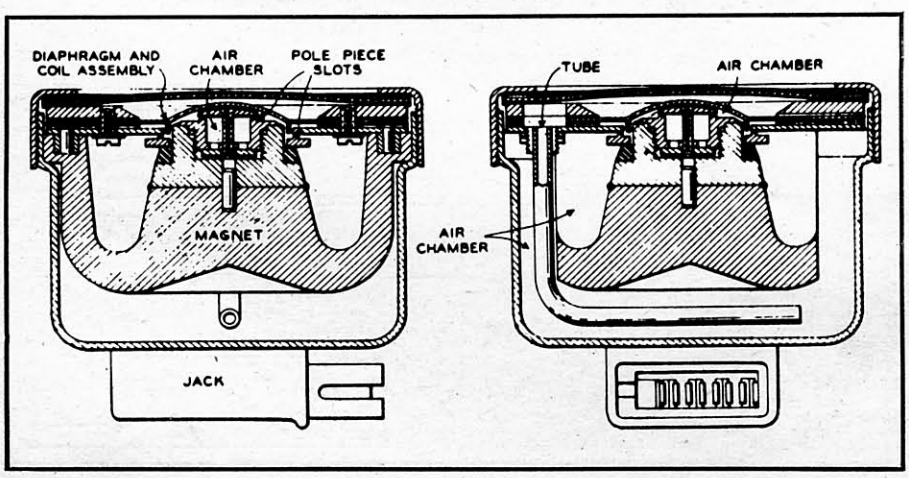
The frequency response is uniform with respect to distance from the sound source excepting, of course, the frequency distortion caused by reverberation within the room in which the microphone is used. In a hard, untreated room this effect can be serious when working more than a foot or so from the instrument. Pressure microphones usually have comparatively stiff diaphragms and are therefore not as susceptible to wind and breath.

Carbon microphones of the pressure type are largely used for mobile communications service as mentioned previously. Pressure microphones in the dynamic type are available in high impedance (25,000 ohms) for feeding direct into grid or 50, 250 or 500 ohms for matching a line.

Pressure microphones are excellent all-purpose instruments for conditions where room reverberation, acoustic feedback, and ambient noise are not too severe. The better quality type are desirable for broadcast announcing and remote, public address, amateur communications, and recording. They are recommended for outdoor as well as for indoor work.

[1] Brush Development Co., Brush Technical Bulletin No. 320.
[2] Electro-Voice Microphones.

Fig. 5. Cross-section view of moving coil microphone.



Differential Microphones

This type of microphone was used by nearly all branches of the U. S. Armed Forces in reproducing speech through high surrounding noise. The same basic principle of operation makes it highly desirable for all applications where ambient noise is 100 db. or more. The *Differential*[2] discriminates against the distance of origin and not sound pressure alone. For example, if background noise originating from a foot or more away is the same sound level at the microphone as speech which originates one quarter inch away, the reproduced speech is from 17 to 20 db. higher than the noise, despite the fact that these two sound pressures arrive at the microphone at the same intensity. The *Differential* is made in both carbon and dynamic types and provides high articulation and good quality reproduction. For public address applications, the *Differential* shows remarkable freedom from acoustic feedback. It is essential, however, that they be used closely, to within ¼ inch to ⅜ inch, or speech itself will be attenuated. Basically, the *Differential* is a close talking microphone and is highly effective in reproducing speech under high ambient noise. It is ideally suited for use by railroads in their communications work. As a carbon hand-held microphone, it is used by many airlines and air transportation companies. It is also used by broadcasters for sporting events, such as boat races, where the background noise is high.

Broadcast Microphones

The following paragraphs will deal with several representative types of high quality microphones designed especially for broadcast applications or for use in professional sound recording studios.

Most stations prefer velocity or "ribbon" microphones for studio work, because of their wide-angle pickup and adaptability to various applications, while dynamic or moving-coil microphones are used in outdoor or remote broadcasts where ruggedness plays a major part. Cardioids, of course, are suitable for all applications and receive a good deal of use.

A good example of the moving-coil type of microphone is the *Western Electric* 618-A (Figs. 4 and 5). This microphone has long been used where ruggedness, good frequency response, and ease of handling are requisites, and is especially suited for use in the broadcasting (or public address) of outdoor events. It holds an advantage over the ribbon type in such events in that it is not so easily damaged by reasonably rough handling, is not as sensitive to "blasts" or instantaneous peaks of excessive level, is not adversely affected by wind, and, by virtue of its unidirectional characteristics, aids considerably in the reduction of background noise usually present in outdoor applications.

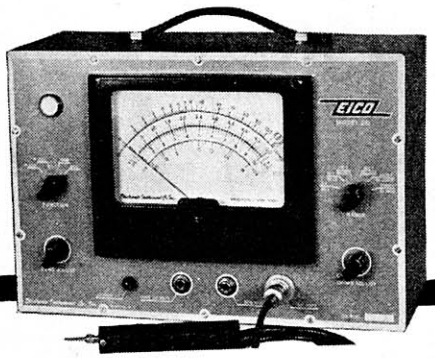
The high-frequency response above

(*Continued on page* 118)



Servicing Simplified FOR AM, FM & TELEVISION

A MUST FOR RADIO REPAIR SHOPS



THE MULTI-ANALYST solves your radio problems quickly—The easiest, most effective method of diagnosis—Saves time—wide frequency response—No frequency controls—Both audible and visual indications—Perfect for checking distortion or fading—This handsome, compact unit contains a complete, stable Vacuum Tube Volt-Ohmmeter—electronic on all ranges—Reads video voltages—Big 4½" meter—Exceptional value..... **$89.50**

THE MODEL 210 VTVM is the perfect instrument for radio repair shop, laboratory, or ham shack—An accurate, stable, high impedance utility instrument with a huge 8½" no squint meter—2% overall accuracy—RF and AC measurements from 30 cycles to 300 mc—Reads to 5,000 volts DC—electronic on all ranges—Resistance measurements from .2 ohm to 1,000 megohms—Complete..... **$65.50**

ELECTRONIC INSTRUMENT CO., Inc.

EICO

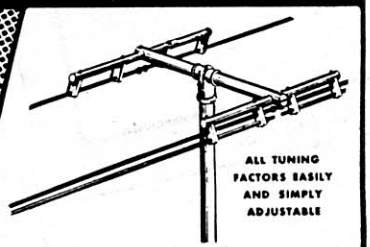
926 CLARKSON AVE. BROOKLYN, N. Y.

Write for FREE illustrated brochure and see your jobbers for a conclusive demonstration.

Complete instruction manual with each instrument.

Licensed by RCA.

★ SHUR ★



NEW, IMPROVED LINE OF ANTENNAS, Featuring:—

- Shur INTERCEPTOR and ANTENNA MOUNT
- The Shur De Luxe INTERCEPTOR
- Shur "JIFFY" line

Designed for simplicity, the "Jiffy" antenna can be assembled in seconds. Insulator units are *preassembled* and require only that the elements be screwed into them. Made for FM band, television band, the 6-meter band and the 2-meter band in the following models:

JD . . . "Jiffy" Dipole

JI . . . "Jiffy" Dipole with Director

JFI . . . "Jiffy" Folded Dipole

JID . . . "Jiffy" Folded Dipole with Director.

The Folded Dipole and the folded dipole side of the JID also have pre-assembled insulator units. While the rest of the Shur antennas are tunable, the "Jiffy" is fixed.

Sold through leading distributors. For further information, write to:—

SHUR-ANTENNA-MOUNT, INC.

EASTERN DIVISION SEA CLIFF, NEW YORK

GOV'T SURPLUS

TUBES

6V6—Metal	$ .89
5Y3 GT	.45
No. 80	.45

Choke, Thordarson, 12H—80 MADC—250 Ohm	$1.09
55 MMF FEED Through	20 for 1.00
.02—1600V Paper	10 for 1.00
.1—600V Paper	10 for 1.00
Resistor Kit—½ & 1 W assorted	2.00
Condenser Kit—.01—.00001—100	3.00
Bathtubs—3X .1, 5, .1 etc. 400 V & 600V	10 for .89
Rect. Selenium G. E. 28V, 300M	.50

OIL-FILLED CONDENSERS—G.E., C.D., ETC.		
10	600 V	$ .80
8	600 V	.70
8	1000 V	1.75
6	2000 V	2.95
4	600 V	.50
4	1000 V	1.00
2.	1000 V	.60
.05	1000 V	.30
.1	2500 V	.95
.1	7500 V	3.25
.5	1000 V	.20
.5	2000 V	.40
1.	600 V	.20
1.	1000 V	.75
2.	600 V	.35
3 x .2	4000 V	3.95
3 x 10	90 V AC	.40
10 x .25	600 V	.20
.75	2000 V	.55

TRANSMITTING MICA CONDENSERS		
.002	600 V	$ .08
.002	2500 V	.27
.003	2500 V	.33
.001	2500 V	.18
.004	2500 V	.36
.00005	2500 V	.11
.005	600 V	.08
.0005	2500 V	.15
.002	3000 V	.66
.00005	5000 V	.95
.00025	5000 V	.95
.00072	5000 V	.95
.0008	5000 V	.95
.0015	5000 V	.95
KIT of 12		3.98
.12	15000 V	6.95
.25	4000 V	2.75
.25	6000 V	4.00

$2.00 min. order F.O.B., N. Y. C. Add postage. 50% deposit, balance C. O. D. with all orders. Manufacturers inquiries invited.

TECHNICAL RADIO PARTS CO.

265 Greenwich St. Dept. N-3, N. Y. 7, N. Y.

Sound Recording

(*Continued from page* 64)

1000 cycles can be altered considerably by changing the degree of angle of incidence, that is, by rotating the frontal surface of the microphone in a horizontal plane so that impinging sound waves strike the diaphragm at an angle other than that of the usual zero degrees as formed by the arrival of sound waves from a point directly in front of the microphone. (See Fig. 6). Low frequency response is not appreciably affected by such angular changes.

By studying the cross-sectional cutaway shown in Fig. 5, one gains an insight into the extreme simplicity of construction. The microphone elements are housed in a metal shell and covered with a metal grill and silk cloth to prevent damage from foreign particles and to minimize dust collection. A metal ring which screws over the housing holds the diaphragm in place. The microphone itself consists of a circular duraluminum diaphragm to which is attached a coil of aluminum ribbon, wound in an edgewise manner and suspended in the radial field of a cobalt steel permanent magnet. Movement of the diaphragm and its associated coil cuts the magnetic lines of force surrounding the magnet and generates an alternating output voltage which is proportional to the magnitude of the original sound waves.

An explanation of the improvement in frequency response of this microphone over that of previous types lies in the inclusion of an acoustic compensating circuit which consists mainly of a properly designed air chamber between the housing and microphone elements and an air vent tube, the length and diameter of which control the compensating action of the air chamber. These constants have been critically adjusted at the factory and should not be altered in any manner.

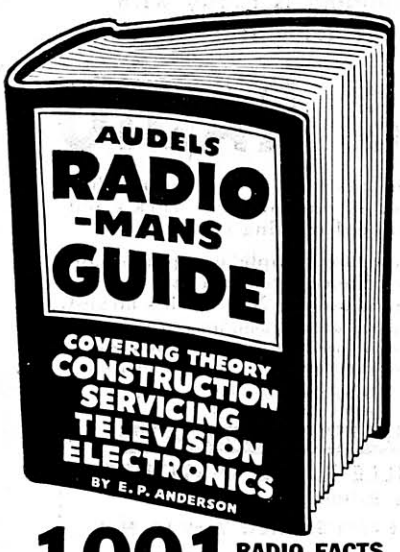
The output of the 618-A is approximately —84 db., and its output impedance, like that of most dynamic or pressure operated microphones, is 30 ohms.

The Nondirectional Dynamic

An improvement over the 618-A is the *Western Electric* 630-A, familiarly known as the "Eight-Ball" because of its sphere-shaped housing (Fig. 7).

It is well-known that any object placed in the field of either primary or reflected sound waves will cause a diffraction of those waves. When the object is a microphone, such diffraction results not only in angular distortion but, more important, causes a change of pressure of the sound waves reaching the diaphragm. The amount of pressure change is dependent not only on the angle of incidence and frequency of the approaching sound waves, but also on the physical size and shape of the microphone.

PLEASE TEAR OUT THIS AD AS A REMINDER



1001 RADIO FACTS AND FIGURES

AUDELS RADIOMANS GUIDE—914 Pages, 633 Illustrations, Photos, Wiring Diagrams, 38 Big Chapters, covering Radio Theory, Construction, Servicing, including Important Data on Developments in Television, Electronics and Frequency Modulation, Review. Questions and Answers, Calculations & Testing. Highly Endorsed—Indispensable for Ready Reference and Home Study.

$4 COMPLETE • PAY ONLY $1 A MONTH

Step up your own skill with the facts and figures of your trade. Audels Mechanics Guides contain Practical Inside Trade Information in a handy form. Fully illustrated and Easy to Understand. Highly Endorsed. Check the book you want for 7 days' Free Examination.

Send No Money. Nothing to pay postman.

CUT HERE

MAIL ORDER

AUDEL, Publishers, 49 W. 23 St., NEW YORK 10, N. Y.

Please send me postpaid for FREE EXAMINATION books marked (x) below. If I decide to keep them I agree to mail $1 in 7 Days on each book ordered and further mail $1 monthly on each book until I have paid price. Otherwise, I will return them.

- ☐ RADIOMANS GUIDE, 914 Pages . . . . . $4.
- ☐ ELECTRICIANS EXAMINATIONS, 250 Pages . 1.
- ☐ WIRING DIAGRAMS, 210 Pages . . . . . 1.
- ☐ ELECTRICAL DICTIONARY, 9000 Terms . . 2.
- ☐ ELECTRICAL POWER CALCULATIONS, 425 Pgs. 2.
- ☐ HANDY BOOK OF ELECTRICITY, 1340 Pages 4.
- ☐ ELECTRONIC DEVICES, 216 Pages . . . . . 2.
- ☐ ELECTRIC LIBRARY, 12 vol., 7000 Pgs., $1.50 vol.
- ☐ OIL BURNER GUIDE, 384 Pages . . . . . 1.
- ☐ REFRIGERATION & Air Conditioning, 1280 Pgs. 4.
- ☐ POWER PLANT ENGINEERS Guide, 1500 Pages. 4.
- ☐ PUMPS, Hydraulics & Air Compressors, 1658 Pgs. 4.
- ☐ WELDERS GUIDE, 400 Pages . . . . . 1.
- ☐ BLUE PRINT READING, 416 Pages . . . . . 2.
- ☐ SHEET METAL WORKERS Handy Book, 388 Pgs. 1.
- ☐ SHEET METAL PATTERN LAYOUTS, 1100 Pgs. 4.
- ☐ AIRCRAFT WORKER, 240 Pages . . . . . 1.
- ☐ MATHEMATICS & CALCULATIONS, 700 Pgs. . 2.
- ☐ MACHINISTS Handy Book, 1600 Pages . . . 4.
- ☐ MECHANICAL Dictionary, 968 Pages . . . . . 4.
- ☐ AUTOMOBILE GUIDE, 1540 Pages . . . . . 4.
- ☐ DIESEL ENGINE MANUAL, 400 Pages . . . 2.
- ☐ MARINE ENGINEERS Handy Book, 1280 Pages 4.
- ☐ SHIPFITTERS Handy Book, 272 Pages . . . 1.
- ☐ MECHANICAL DRAWING COURSE, 160 Pages 1.
- ☐ MECHANICAL DRAWING & DESIGN, 480 Pgs. 2.
- ☐ MILLWRIGHTS & Mechanics Guide, 1200 Pgs. 4.
- ☐ CARPENTERS & Builders Guides (4 vols) . . 6.
- ☐ PLUMBERS & Steamfitters Guides (4 vols.) . 6.
- ☐ MASONS & Builders Guides (4 vols.) . . . . 6.
- ☐ MASTER PAINTER & DECORATOR, 320 Pgs. 2.
- ☐ GARDENERS & GROWERS GUIDES (4 vols.) 6.
- ☐ ENGINEERS and Mechanics Guides Nos. 1, 2, 3, 4, 5, 6, 7 and 8 complete . . . 12.
- ☐ Answers on Practical ENGINEERING . . . . 1.
- ☐ ENGINEERS & FIREMANS EXAMINATIONS . 1.

Name_____

Address_____

Occupation_____

Employed by_____ RN

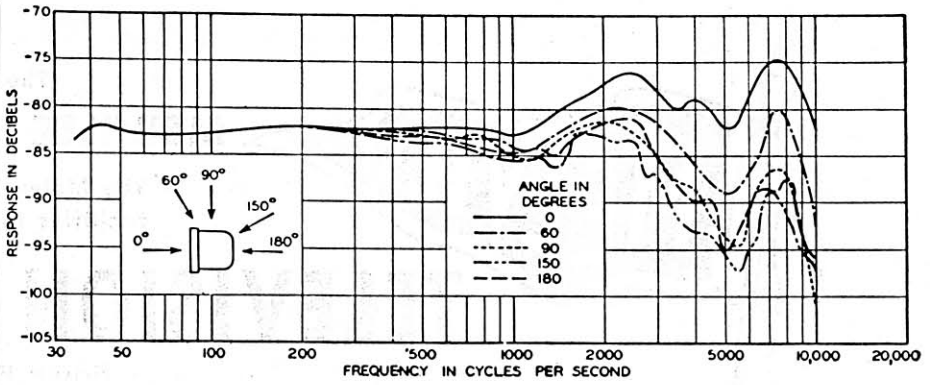


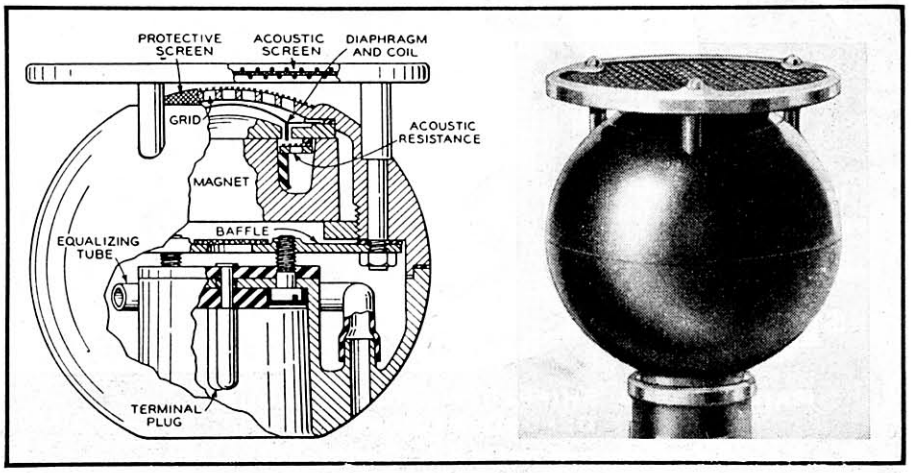
Fig. 6. Angular response of moving coil microphone.

Because of a tendency to discriminate between various angles of wave frequencies above 1000 cycles, the microphone assumes a directional characteristic whose factor does not maintain a fixed value, but rather varies in accordance with changes in both the frequency and in the angle of incidence of the impinging sound waves. This action gives rise to phase distortion in the output of the microphone. Since the over-all size of the microphone is one of the basic factors involved, it is assumed that this problem could be solved by decreasing the physical dimensions of the housing and microphone elements. However, theoretically, a microphone so constructed as to present no angular discrimination over the normal audio frequency range would be impractical because of its extremely small size, delicate construction, and inherent loss of output. Such a unit would require that an additional preamplifier be used. It, therefore, holds that the shape of the housing, which is another basic factor, is the solution to this particular problem.

Tests made by engineers of the *Bell Telephone Laboratories* on the effects of various shaped objects on sound wave diffraction, produced conclusive data which resulted in the selection of the spherical-shaped housing as the best suited in reducing directional distortion. Referring to the cross-sectional diagram in Fig. 7 it can be seen that the microphone is divided into two parts, with the microphone itself, comprised of diaphragm, coil, magnet, and acoustic resistance, in the top of the shell. The lower half, whose bottom section is recessed to hold the connecting terminal plug, contains an air chamber and equalizing tube. This rubber tube, cut to its proper length at the factory, is used to increase the low frequency response and to compensate for differences in air pressures inside and outside the shell. The two halves are separated by an acoustic-resistance baffle, which essentially is a flat metal plate perforated by six one-half inch holes to provide acoustic continuity between both sections of the housing. This baffle is used to prevent the occurrence of cavity resonance within the housing itself.

Ordinarily a microphone having its diaphragm mounted in a horizontal plane and normally facing upwards, exerts a marked tendency toward giving better frequency response to high-frequency waves reaching the diaphragm from various angles above the horizontal plane than for corresponding waves reaching it from below. This condition was overcome by the employment of an acoustic screen. This screen, two and one-half inches in diameter and surrounded by a protective metal ring, is composed of a wire mesh screening on either side of several layers of treated silk cloth, and mounted horizontally about one-eighth inch above the front of the diaphragm. By virtue of its resistance to

Fig. 7. The familiar Western Electric "Eight-Ball" microphone.



RADIOMEN! ELECTRICIANS!

240 Page BOOK on "HOW TO START A SHOP OF YOUR OWN"



FREE

Here's an unusual "get acquainted" offer! This new 1947 book, "Starting & Operating a Profitable Electrical or Radio Business" is yours, absolutely FREE! It tells how to start and run a paying service shop **right**, on small capital, full or part time. Packed with practical information to help you get ahead in a shop of your own or working for some one else.

10 to 1 Satisfaction GUARANTEE

"I personally guarantee that at the end of 1 year from date of receipt, my "Applied Practical Radio" set will have earned for you at least 10 times its cost, or you may return it and I'll return every cent you paid."



B. W. Cooke, Pres.

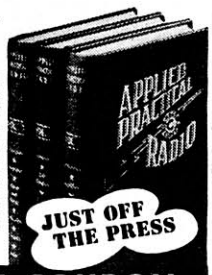
HOW TO GET YOUR FREE BOOK

You get this book Free just for looking over—without cost or obligation—the sensational new 3-volume Coyne set "APPLIED PRACTICAL RADIO". It's **just off the press.** Here's everything you want to know about radio, from basic principles to up-to-the-minute Television and FM! PA, short-wave, aviation-auto radio, multi-bands, tele-transmission, etc., all clearly explained. Shows how to construct, install, service all types of apparatus. Step-by-step photos break equipment down before your eyes! Newest testing methods. Hundreds of subjects, almost 1000 pages, 600 illustrations, diagrams. Written for home training and field reference—so complete, so up-to-date and practical that every man interested in radio should see it.

SEND NO MONEY! You can see how much this Set can mean to your future, without cost or obligation. I'll send "APPLIED PRACTICAL RADIO" postpaid, for you to look over for 7 days FREE—and **with** it, the "Business Starting" book as an outright Gift! **This book is yours to keep free whether or not you decide to keep the 3-volume set!**

Coupon Is Not an Order Just a Request to See the Set Free

You are not buying the 3-volume set when you send this coupon. You are merely asking to see the books free for 7 days. This coupon becomes an order only if you decide to keep the set after 7 days Free Examination. Free Book Offer is limited—so mail coupon today.



FREE BOOK COUPON

B. W. Cooke, Pres., COYNE ELECTRICAL SCHOOL, Dept.67-T3, 500 S. Paulina Street, Chicago 12, Illinois.

Send me the NEW 3-Volume Coyne Set, "APPLIED PRACTICAL RADIO". Also send me the book, "Starting & Operating a Profitable Radio or Electrical Business", which I am to keep FREE **whether or not I keep the 3-book Set.** I'll either return the 3-book Set in 7 days and owe nothing, or pay $3 within 7 days and $3 a month until $10.75 is paid—or I'll send the cash price of $9.75. You also include FREE one full year of Consultation Service.

NAME_____ AGE_____

ADDRESS_____

TOWN_____ ZONE_____ STATE_____

☐ Check here if you want to pay postman cash price of $9.75 (you save $1.00) on delivery. Same Money-Back Guarantee after 7 days' trial.

sound waves, the screen tends to reflect waves coming from below the horizontal plane back into the diaphragm, thereby lending valuable sound reinforcement, and also acts to retard sound waves striking the screen from the front. The microphone response to varying degrees of angular sound approach is thereby made uniform.

The diaphragm is mounted as close to the front of the shell as is possible, a feature which is desirable in that the total angle of diffraction formed by the spacing between housing and diaphragm is reduced to a negligible degree, and at the same time a larger area is permitted in the air chamber behind the diaphragm. The useful amount of back-pressure thus formed is an important factor in the reduction of diaphragm vibration impedance. Protection of the diaphragm is afforded by a grid which is so designed as to offer added improvement in high-frequency response. Covering this grid is a screen of silk cloth which protects the diaphragm from possible damage from iron filings, dust particles, and other foreign matter.

Frequency response of this microphone is essentially flat from 40 to 10,000 cycles, without regard to angle of incidence.

Output of the 630-A is approximately —87db., or 3 db. below that of the 618-A, but this slight disadvantage is more than offset by its improved frequency response, lighter weight, compactness, and adaptability to a wider variety of uses.

The Velocity Microphone

The "velocity" type of microphone is so called because its action depends on the velocity of air particles rather than sound wave pressure. It is also known as a "pressure-gradient" unit, and more familiarly as a "ribbon."

The design of velocity or "pressure-gradient" units is represented in the development of the *RCA* 44-BX. With a uniform frequency response from 40 to over 10,000 cycles and an output level of —55 db., at a reference level of .001 watt, the 44-BX approaches the criterion in the combination of efficiency, sensitivity, shock resistance and streamlined ruggedness.

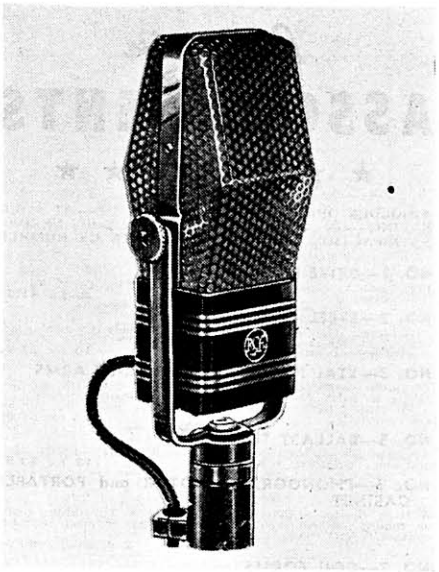
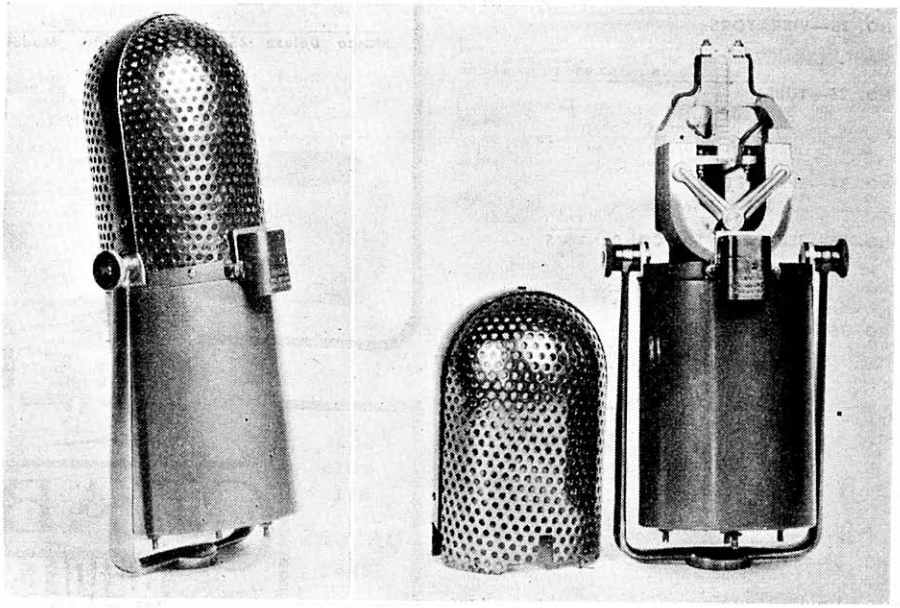


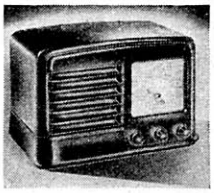
Fig. 8. The velocity microphone which is also known as a "ribbon type."

Construction of the 44-BX lies along conventional lines and is shown in Fig. 8. A thin corrugated aluminum ribbon, so designed and constructed that its natural resonant point falls below the lower limits of the audio frequency range, is suspended between the poles of two paralleled sections of a cobalt permanent magnet. As the length of the ribbon is perpendicular with respect to the plane of the magnetic lines of force and its width coincident with that plane, it follows that any movement of the ribbon in response to the pressure-gradient of impinging sound waves will cause the magnetic

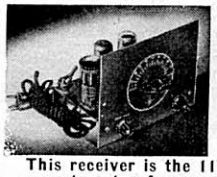
Fig. 9. The RCA Model 77-A (left) and Model 77-D (right).



4 TREMENDOUS VALUES
PROFESSIONALLY DESIGNED RADIO KITS

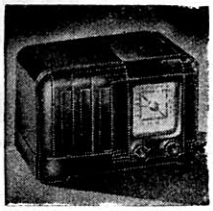


Kit Model FM-7, a splendid, low-priced, self-contained table model Frequency Modulated Radio Receiver Kit Complete with tubes, speaker and beautiful Bakelite cabinet. The FM-7 has a frequency response of 86-110 MC, can also be used as a tuner with a high quality amplifier. A phonojack is provided in the rear of the chassis with double pole, double throw switch control for feeding signal to either the radio speaker or to the phonojack. An additional jack for connecting extra loud speaker is included. The R.F. section of kit is pretuned at factory. This kit uses 2 I.F. stages, 1 limiter stage and 1 discriminator. Miniature tubes used throughout. Price of Model FM-7 complete as described....$29.95



Kit Model R-3, a 3-tube receiver of the regenerative type

This receiver is the 110 volt type and operates at a frequency of 550 Kc to 1500 Kc by means of a plug-in coil. The power supply is self-contained in the receiver thus eliminating the need for a separate power pack.
Price of Model R-3, less tubes..$6.00



Kit Model S-5 uses the universally accepted superheterodyne circuit

Containing the following tubes: 12SA7, 12SK7, 12SQ7, 50L6, 35Z5 and tunes from 550 Kc to 1600 Kc. Price of Model S-5, less tubes.....$10.95



Kit Model 210, a Three Way Portable Receiver
Operating on either AC or DC or self-contained batteries . . . power switch conveniently located on front of set so that "battery" or "AC-DC" may be selected without opening case. Five-inch Alnico 5 permanent magnet dynamic speaker, and case covered with weather tested aircraft material.
Price of Model 210, complete with tubes.....$18.95

All kits accompanied by a detailed, illustrated instruction sheet.
Many other kit models available, write for catalog K.

RADIO KITS COMPANY 120 CEDAR STREET NEW YORK 6, N. Y.

SENSATIONAL SELLER!



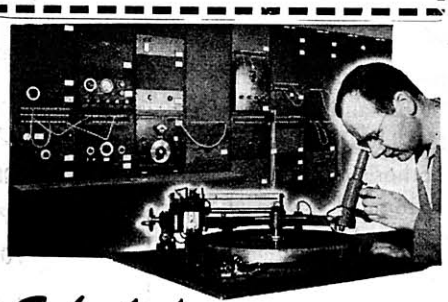
LAKE DELUXE CHANGER
Revolutionizes the Industry!
A Sensational Seller!
11 Outstanding Features:

- Positive Intermix
- Service Adjustments Eliminated
- Minimizes Record Wear
- Single Knob Control
- Plays ALL Records
- Completely Jamproof
- Records Gently Lowered on Spindle —not dropped
- Automatic Shut-off on last record
- Pick-up arm may be grasped at any time and changer will not be thrown out of adjustment
- Resonance-free ball bearing tone arm
- Easily operated—any child can do it

Dimensions: 13 13/16"W x 12¼"D x 7⅜"H. No. 116A.....YOUR NET **$28.73**

SERVICEMEN—RETAILERS
Write for our new, illustrated 16-page catalog NR-116. It's free. Get on our mailing list!
Write for our Special Catalog on Microphones, Amplifiers and Sound Equipment!

Lake Radio Sales Co.
615 W. Randolph Street
DEPT. A
Chicago 6, Ill.



School of SOUND RECORDING and TRANSMISSION ENGINEERING

Learn sound recording and transmission engineering techniques of the professionals, as used in Motion Picture, Broadcast, F-M, Television, and Commercial Recording Studios.



A nine months practical engineering course, devoted exclusively to the technique of sound recording and transmission measurements. Well equipped studios, professional recorders and circuit laboratory containing latest model test equipment installed for student training. A portion of our laboratory is pictured above.
• New classes admitted the first School day of Jan., Apr., July, Oct.

H. M. Tremaine Director

Affiliated with the Don Martin School of Radio Arts
Approved for Veterans

Write for Literature • Sound Department
***Don Martin* SCHOOL of RADIO ARTS**
1655 Cherokee • Hollywood 28, California

lines of force to be cut in a transverse manner. By virtue of its extreme lightness and sub-audible resonant period, the ribbon allows uniform response over the entire audio frequency range without undue frequency discrimination or tendency toward cavity resonance effects. As a result, a properly designed ribbon displays excellent frequency response characteristics, with a relatively high voltage output.

Maximum sensitivity is evidenced toward sound waves approaching the microphone at an angle of 90 degrees to the plane of the ribbon, with a corresponding loss of sensitivity to waves approaching at an angle of lesser degree. Since sound waves traveling in a plane identical to, or parallel to, the plane of the ribbon exert little or no pressure upon it, the resultant response pattern of the microphone becomes sharply bidirectional. Specific applications in which this characteristic may be used to best advantage will be discovered by experimenting with individual setups.

The Unidirectional Velocity Microphone

In the *RCA* 77-A unidirectional microphone (Fig. 9) the principle of operation, by virtue of the unique manner in which the ribbon is constructed, is much the same as that of the cardioid microphone. The corrugated ribbon is suspended vertically between the two halves of a permanent magnet, the field of which is cut in the usual transverse manner. The ribbon, however, is divided into two equal sections which operate independently of each other, the upper half being responsive to the pressure of sound waves and the lower half actuated by air particle velocity and acting as a conventional ribbon unit.

The upper section is made to operate as a pressure unit by allowing the ribbon to vibrate freely as usual, but with the back section enclosed in a metal housing terminated in an infinite impedance in order to prevent a rising response characteristic at the higher frequencies. A practical means of attaining such an impedance is by the use of a number of metal plates approximately ¾ inch thick and 4 inches in diameter, placed one upon the other to form a cylinder. The inside portion of each plate is spiral-shaped, with a small opening at the beginning and end of each spiral which corresponds with a like aperture in each succeeding layer of plates to form a continuous labyrinth, each layer being loosely packed with absorbent material to aid in reflection damping.

In the *RCA* 77-B, a long hollow tube, tightly packed with absorbent felt padding and coiled to facilitate overall compactness is used instead of the cylindrical labyrinth.

Since the output of the pressure unit may be expressed as unity, and since the bidirectional response is equal to the cosine of the angle of approaching sound, the combined output can be expressed as $E = E_o\ (1 + cos\ \theta)$, or

HERSHEL BEATS BARGAINS

WITH LOWEST PRICES ON QUALITY MERCHANDISE!

Radio Tubes

813	$ 5.45
RK60	1.25
VT127	2.95
VR150	.69
829	2.45
872	1.95
955	.65
9004	.65
6J4	1.50
6J6	.95
3APT	2.45
3BP1	2.45
5BP1	3.95
5CP1	3.45
5FP7	3.45
7BP7	4.45
9LP7	5.45
304TH	6.95
1T4-3S4-3Q4-6SN7-6SL7-6SA7-5U4G-5W4-35W4, ea.	.59
5U5B	.79

Condenser

Cat. No.	CAP. MFD.	Working Volts	Your Cost
C110	1	5000 Oil	$ 3.95
C112	1	1000 Oil	.44
C114	8	600 Oil	.95
C115	2	600 Oil	.49
Westinghouse 1 MFD 6000 volts WVDC			7.95
Westinghouse 1 MFD 10,000 volts WVDC			12.95
General Electric 25 MFD photo flash pyranol-capacitator, 2000 VDC-INT.			14.95
IRC type HE resistor 200 wt. tapped at 3000, 7500, 23,750 ohms, Brand new			.49
144 MC Radar Osc. uses 15E or with variable coupling. Complete less tube			3.95
Thordarson 300MA Power Transformer 100 or 220 V 60 cy. input. Secondary: 500/ct/500 tapped at 450/450. Extra bias winding 200/ct/100 at 50ma. 18 lbs.			4.95
BC 191E less tubes and tuning units			14.95
5V Filament Transformer 60 amps. 22 lbs.			5.95
Ear Phones. 2000 ohms, used—in good condn.			.95
Ass't resistors ½ watt fully insulated in popular ohmages. Cat. No. R-5 per 100			1.49
.1 MFD 7000 WVDC Sprague			1.95
Plate transformer. Shelled Case. 110-V 60 cy. Pri. 800 VAC-200 MA. Sec. not tapped.			3.95
Wafer Sockets, 4-5-6-7 and 8 prong. Cat. No. WF-4 Per 100			2.95
12" Utah P.M. Speaker Alnico No. 5 with 6F6 output transformer. Cat. No. ST-100			6.95
Ass't knobs push on wood and plastic. Cat. No. KP-100—per 100			1.95
Johnson sockets No. 210-25W. Cat. No. JS-210			.49
Sockets for acorn tubes. Cat. No. AT-10			.19
Jacks PL 55, PL 68			.15
1 Meg. Shalicross Acra-Ohm wire wound resistors ± 1W			.89
5 gang app. 50 MMFD per sec.			1.95

BC-654, Transmitter and receiver, used	$14.95
SCR522 Trans. and Rec. with tubes and Xtal 200KC with tube and Xtals like new	29.95
Modulation Transformer 1KW	14.95
Famous Boat Anchor Transmitter and Receiver.	14.95
Scope Supply Transformer 4000V	3.95
30MC IF Transformer	.29
Corona Balls, dozen	1.00
Filament Transformer 110V, 60 cy. pri. Sec. 5V-3A shelled case	1.49
Filament Transformer 110V, 60 cy. sec. 2.5V at 5.25 amps. shelled case	2.45
Filament Transformer 110V, 60 cy. sec. 1.5V at 10 amps. sec. 2.5V at 10 amps. connected in series will give 10V at 10 amps. shelled case	3.95
General Electric meter, type DO41, O-10-MA, or O-500MA 3½" round case, ea	3.95
BC223 AX Transmitter, Brand new	29.95
Variack 1 amp	3.95
Variack 5 amp	7.95
Assorted HF. chokes, dozen	.50

BRAND NEW SCR269F Automatic Direction Finder Radio Compass complete with component parts **75.00**

Minimum order $2.00 f.o.b., Detroit. Michigan sales, add 3% sales tax. 20% Required on all c.o.d. orders.

HERSHEL RADIO CO.
5249 Grand River
DETROIT 8, MICHIGAN

WATCH OCT. ISSUE for Announcement of Hershel's **GIGANTIC SALE**

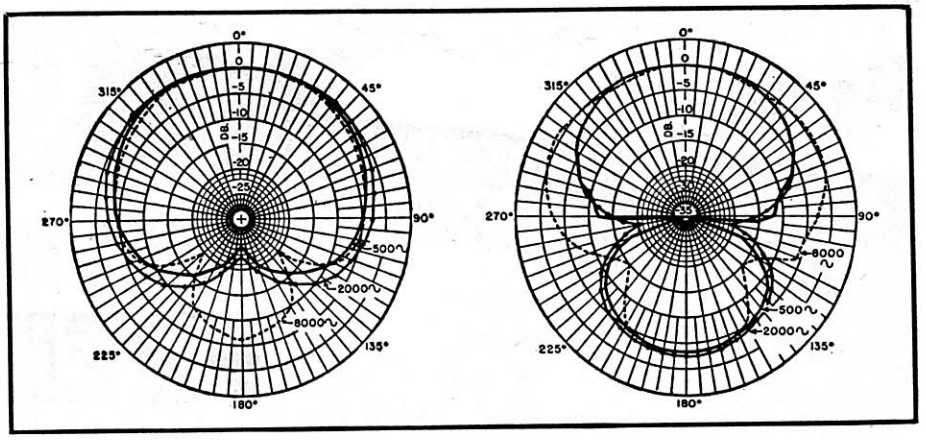


Fig. 10. Frequency response characteristics of the WE 618-A.

the familiar cardioid directive pattern.

This type of microphone has an output level of approximately −81 db., where 0 db. = 1 volt per bar (open circuit voltage) across a 250 ohm output impedance.

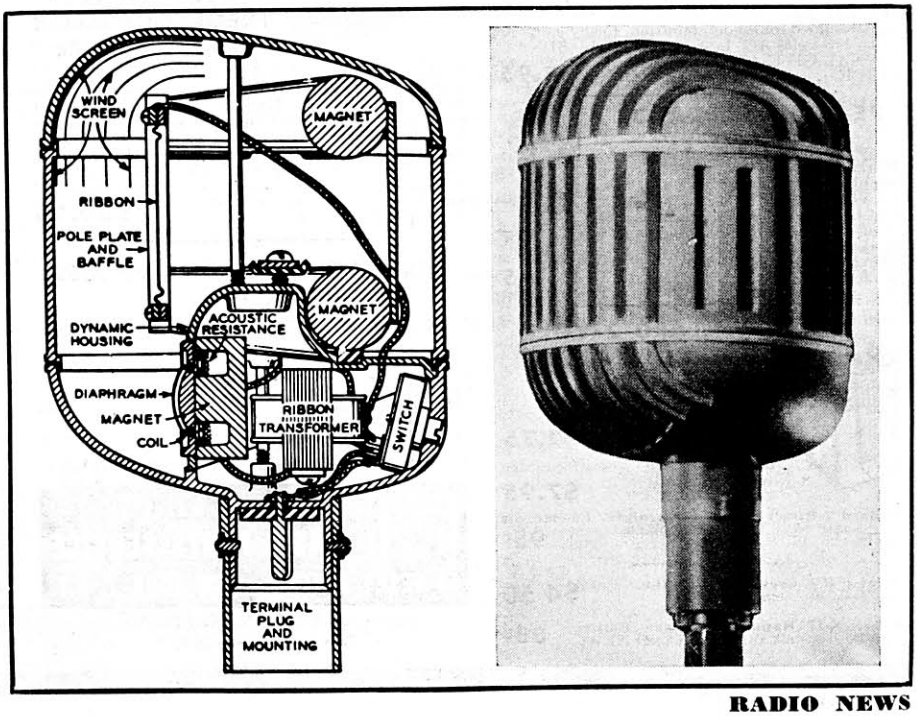
Referring to the characteristic pattern shown in Fig. 10, it is seen that maximum response is afforded to sound waves approaching at right angles to the lateral plane of the ribbon from the front side, while the small lobe as evidenced at the rear in the response pattern indicates practical elimination of sound waves from this direction. The advantages of such a pickup pattern lend the microphone to a variety of applications.

The Cardioid Microphone

An explanation of cardioid directivity is best given through a detailed examination of the characteristics of a typical cardioid microphone. Such a microphone is the *Western Electric* 639-A (Fig. 11), whose directive pattern resembles the heart-shaped or "cardioid" plot of the mathematical term $(1+\cos\theta)$, hence its name. This pattern, which makes possible a wide-angle pickup of 120 degrees, is the result of the utilization of the combined outputs of a nondirectional dynamic unit similar to that of the 630-A and mounted vertically as a semidirectional unit, and a specially constructed bidirectional ribbon unit, both being housed in the same case.

It is well known that sound will flow around corners or curved surfaces and since the case holding the dynamic unit is so designed, sound waves approaching from the back of the microphone follow the rounded contour of the case to the front of the diaphragm, thereby causing it to move in the same direction in response to sound waves arriving from the back and sides as to those arriving from the front. Thus the diaphragm always moves in one direction only, and the output of the microphone maintains a constant phase relation. For this reason its output may be represented mathematically by a whole number, such as 1, or unity. The bidirectional velocity

Fig. 11. The Western Electric 639-A cardioid directional microphone.



unit, however, responds to sound waves approaching from two opposite directions, and as a result the ribbon reverses in phase each time the direction of sound is reversed. This phase reversal is proportional to the cosine of the angle of the approaching sound, and a combination of the two outputs $(1+\cos\theta)$ approximates the true cardioid.

The unique structure of the ribbon allows a practically uniform response over the low and high frequencies as well as the middle frequency range. Normally, a conventional ribbon unit, when used in conjunction with a dynamic unit, tends to discriminate to some degree all frequencies above and below a certain medium range, resulting in an unbalanced condition of pickup with accompanying frequency distortion.

Physically, the ribbon designed for the 639-A is less than half the length of an average ribbon, is decidedly narrower, and is corrugated at either end, with its center section straight in relation to the front of the microphone. Since this portion is concave to the back of the microphone, it presents slightly more acoustical resistance to sound waves traveling in this direction than to those arriving from the front, thus aiding in equalizing the pickup from both directions, and presenting a closer approach to a true bi-directional pattern. This form of ribbon construction also affords less resistance to wind, prevents possible twisting of the ribbon, and contributes to its over-all ruggedness.

General construction of the 639-A is shown in the cross-sectional diagram of Fig. 11. The three-position switch in back of the housing is slotted for screw-driver operation, and allows selection of three directional patterns—*C* for cardioid, in which both units are combined; *D* for dynamic, in which the pressure unit alone is connected; and *R* for ribbon. In the 639-B six positions are available, the extra three being used to give varying degrees of directivity to the cardioid pattern.

Output impedance of the 639-A is 30 ohms, and its output level is −85 db. with reference to 1 volt/bar or .006 watt.[3]

[3] Ledbetter, John B., "Broadcast Microphones" Radio-Electronic Engineering Edition of Radio News, June, 1946.

(To be continued)



"See? You can stick your hand into it and—OH! oh! wrong fan!"

Only YOU hear it!



Hushatone special design gives it excellent tone quality when used under pillow or similar covering.



Small extension unit has excellent fidelity.



Compact — Hushatone is only 4 3/16" in diameter and 1 1/16" thick. Slips easily under pillows wherever needed.

New miniature under-pillow unit means end to "radio irritation"...

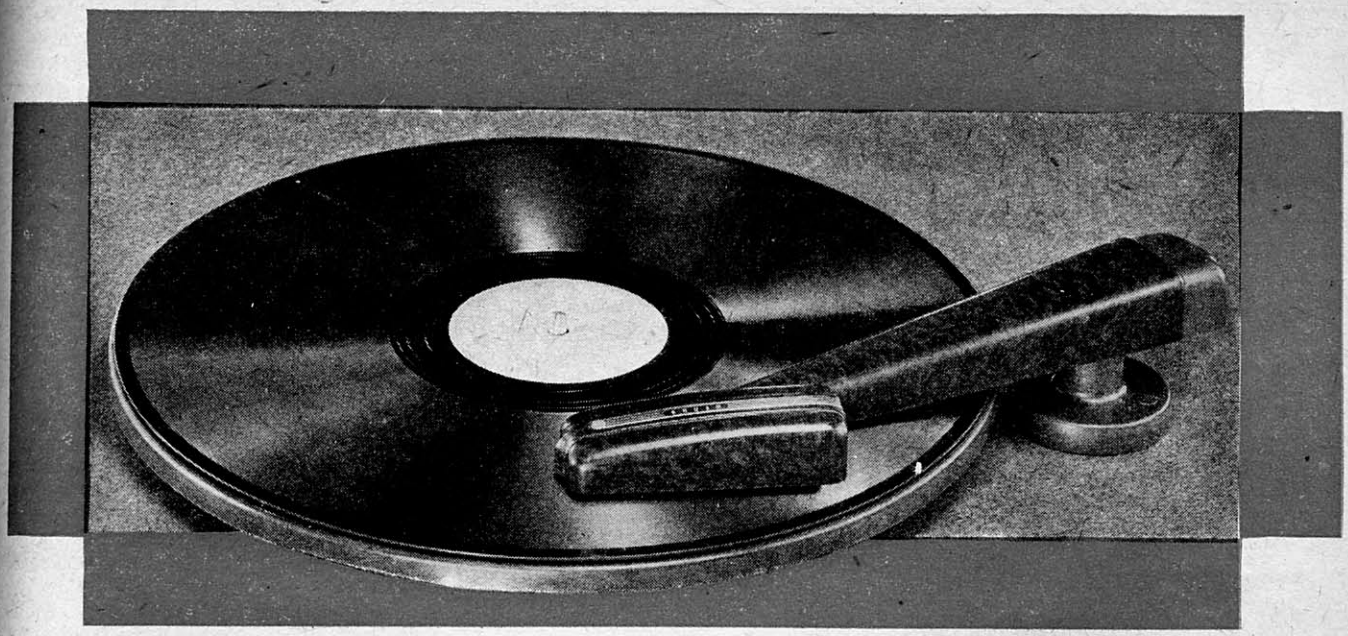
The Hushatone* is a small, streamlined under-pillow unit which assures private radio enjoyment without disturbing others. It's compact—only 4 3/16 inches in diameter, 1 1/16 inches thick. Cannot be felt under bed or sofa pillow. Special design assures tone quality comparable to full-size radio. Easily connected to radios. Can be dipped into disinfecting solution —washable (hermetically sealed). Complete with convenient, durable cord. At radio dealers everywhere.

Hushatone*

a product of The Brush Development Co.

3405 Perkins Avenue Cleveland 14, Ohio

*Trade Mark Reg. U. S. Pat. Office



Brush PL25 crystal pickup uses correctly balanced offset cartridge.

The Recording and Reproduction of SOUND

By OLIVER READ
Editor, RADIO NEWS

Part 8. A discussion of representative crystal cartridges and the various methods of coupling which may be used to give best reproduction.

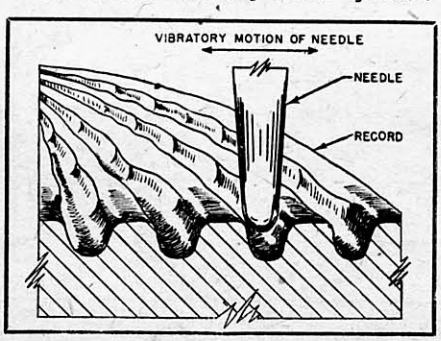
ONE of the greatest contributing factors to the successful reproduction of voice and music through electronic systems is the development of the modern pickup. These units are found in a variety of shapes and sizes and are usually divided into the following classifications; 1. magnetic, 2. crystal, and 3. moving coil. It should be explained, however, that there are many varieties and versions of each. From the most inexpensive type commonly employed in the average home phonograph, to the elaborate precision made instruments designed specifically for broadcast and high fidelity recording and reproduction, we find various shapes, sizes, etc., in use.

Since around 1930, the electric phonograph and radio-phonograph combinations for homes have appeared on the market in ever increasing numbers. Performance has steadily improved through the years to such a degree that reproduction of recorded sound today leaves little to be desired.

The success of these devices, as far as home recording is concerned, is due largely to the development and improvement of pickup cartridges using crystal elements of Rochelle salts (sodium potassium tartrate). The use of this substance has resulted in improvements such as decreased needle pressure, higher output voltage, and wider frequency response.

The home recorder may employ an inexpensive preamplifier and omit complicated equalizers in conjunction with the modern crystal phono pickup and still obtain satisfactory reproduction of commercial records. The voltage developed by crystal cartridges of this type is sufficient to enable them to perform satisfactorily with ordinary low gain type amplifiers. The comparatively low cost of crystal phono cartridges, together with their other advantages, has permitted radio and phonograph manufacturers to produce equipment for home use priced within the means of almost everyone.

Fig. 1. Greatly enlarged cross-sectional view shows needle following record grooves.



The Crystal Pickup

Back in 1880, Madame Curie, working with her husband, discovered that certain crystals would develop electrical charges on their surfaces when subjected to mechanical stresses. This phenomenon became known as the piezoelectric effect (electricity developed due to pressure or torsion). This is the principle upon which a crystal pickup cartridge functions.

The needle, following the groove of a record upon which sound has been recorded, is vibrated in proportion to the amplitude of the recorded sound. See Fig. 1. This vibration is imparted to the crystal element through a needle chuck or torque wire assembly or variations thereof. The illustration, Fig. 2, shows the construction of a low needle pressure type cartridge and a conventional removable needle type cartridge.

In both of these types a torsional crystal element (twister) is used and is so mounted that the needle vibration imparts torsional forces to the crystal element. The motion of the

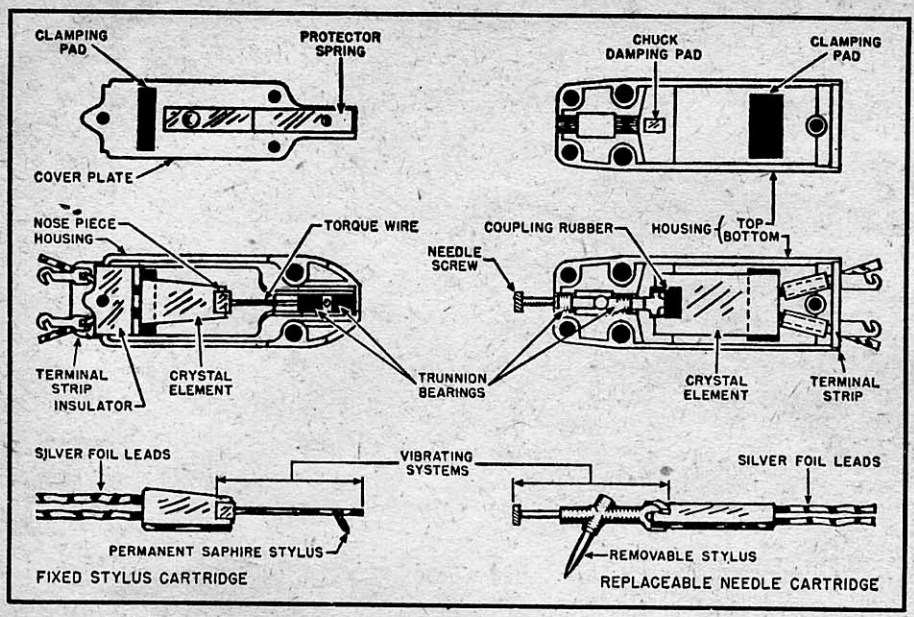


Fig. 2. Note the differences in construction between the fixed needle (left) and the replaceable needle (right) cartridge.

vibrating system is almost entirely absorbed by the twisting of the torque wire in the low pressure cartridges and the flexing of the coupling rubber in the conventional type so that the crystal, practically speaking, does not vibrate. However, the flexing of the torque wire or coupling rubber applies forces to the crystal directly proportional to the needle motion. The crystal generates voltages corresponding to these forces. Various types of rubber and other damping materials, such as Viscoloy, etc., are used for controlling output voltage, frequency response and other characteristics.

Crystal cartridges are made in a great number of styles with a wide variety of electrical characteristics in order to accommodate a multitude of various applications. The size, shape, and required needle pressure of a cartridge has a great deal to do with the styling of the pickup arm. The output voltage and frequency range of the cartridge are factors taken into consideration by equipment manufacturers when they are designing the amplifier and speaker combination with which the cartridge is to be used. Much time is spent on the circuit design of an amplifier, and a crystal cartridge used for reproduction of records becomes one of the basic components of the amplifier input circuit.

It is well-known that the various components of any circuit cannot be replaced with any but those of like characteristics without disturbing the circuit balance or changing the performance of the equipment. When it becomes necessary to replace a crystal phonograph cartridge, this should be done with an exact duplicate or substitute of the original in order to obtain optimum results.

Requirements

The technical specifications for pickups and cartridges should be consulted prior to making selections or recommendations. Information concerning output voltage, needle pressure, and frequency range is of particular interest and value. Selection of the proper pickup and accurate installation will determine to a great extent the type of reproduction which may be obtained.

Great care should be exercised when installing a pickup arm to make sure that the motor board is perfectly level and that the pickup is mounted squarely, that is, on a direct plane with the surface of the record. Otherwise the needle will not properly track the record grooves. This would cause excessive needle and record wear. If the amplifier with which the pickup is to be used is of the high-gain, high-output type and it is necessary that the volume be kept at high level, it may be advisable to install a pickup and turntable mechanism in a compartment or cabinet separate from the speaker, in order to prevent feedback.

Certain types of turntable motors may cause a considerable amount of turntable vibration which may produce a disagreeable rumbling noise. Before installing a pickup on the motor board of a turntable using such a motor, the direction of maximum vibration should be determined. Following this, the pickup arm should then be installed so that it is parallel with the vibrating motion. Observance of this precaution will do much toward preventing this rumbling.

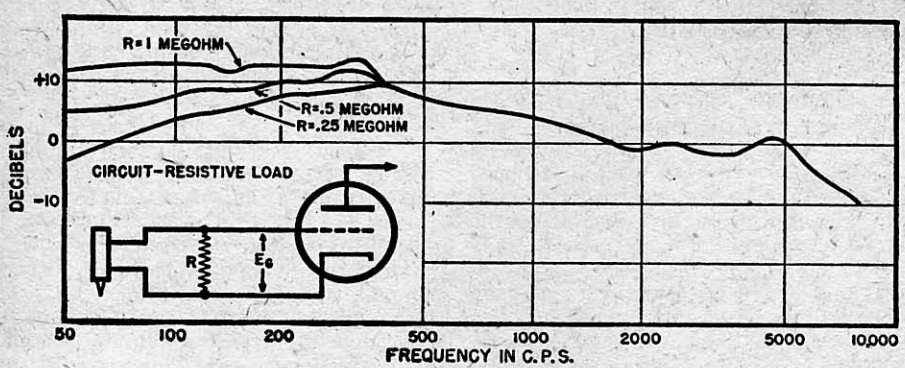
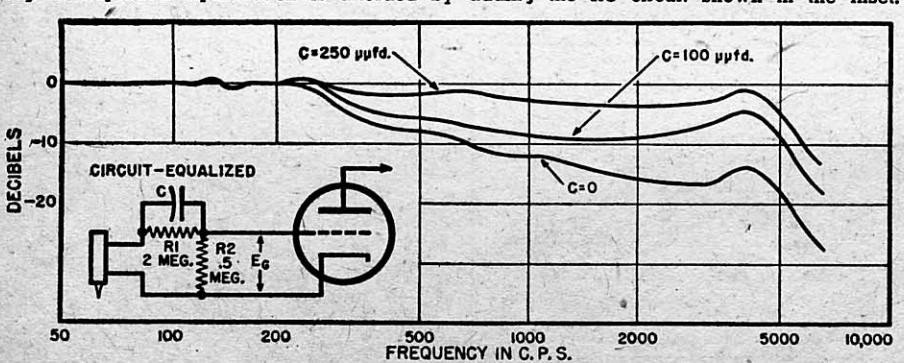


Fig. 3. Decreasing the value of R decreases bass response. A .5 megohm load is normal.

Fig. 4. Improved equalization is afforded by adding the RC circuit shown in the inset.



Equalizers for Crystal Phonograph Pickups

It is sometimes advisable and often necessary, due to the many individual tastes involved, that an equalizer be employed in the input circuit of an amplifier in series with the phonograph pickup in order that the response of the pickup be entirely satisfactory to the listener. This is especially true of radio receivers or amplifiers which were not originally designed for phonograph operation. An understanding of the proper application of equalizers, to be covered later, is of great help to the serviceman called in for consultation and advice by the listeners whose equipment does not have enough low frequency or sufficient high frequency response to suit them.

Crystal pickup cartridges are high

impedance devices and should, therefore, be connected across a high resistance load. The usual value employed is .5 megohm. By decreasing this value the low frequency response of the pickup cartridge may be decreased, while increasing the value will increase the low frequency response of the cartridge. See Fig. 3. However, if this value is made either too high or too low, the bass and treble balance of the cartridge may be upset. In addition, the over-all performance would be quite unsatisfactory. For best results with average crystal cartridges this value must be kept between .25 megohm and 1 megohm.

With the value of low resistance being adjusted for optimum low frequency response (optimum in this case being that which is most satisfying to the individual listener), the pickup may be further compensated by using the equalizer circuit shown in Fig. 4. The value of capacitance to be used is usually between 50 $\mu\mu$fd. and 500 $\mu\mu$fd., depending on the amount of high frequency response desired. R_1 may be between 1 megohm and 5 megohms.

When the total value of R_1 and R_2 is 2 megohms, maximum bass response is obtained. Any further increase in the value of R_1 has no further effect on the low frequency response of most cartridges. Further increase in the value of R_1 does, however, minimize the effects of increased temperatures on the low frequency response. As the temperature increases, the low frequency response of the cartridge has a tendency to decrease slightly and if a condition exists where the operating temperature varies between normal room temperature (approximately 70° F.) and 100° to 110° F., it may be advisable to employ a higher value of resistance for R_1.

It should be noted that as the value of R_1 is increased, the value of capacitance should be decreased proportionately. Another important factor to remember is that when a circuit is equalized there is necessarily a reduction in output of the cartridge and, therefore, it may be that increasing the value of R_1 will not allow sufficient excitation voltage to reach the input tube grid to enable the amplifier to deliver its full rated power output. If this is the case, it is best that the total values of R_1 and R_2 be held to 2 megohms or less. By using a slightly more elaborate circuit, such as is shown in Fig. 5, both high and low frequency response may be varied independently. One switch is used to control the low frequency response while the other switch is used to control the high frequency response.

Temperature and Humidity Effects

Crystal devices employing Rochelle salt crystal elements function best at temperatures between 70° and 80° F. when the relative humidity is approximately 50%. They are very much like human beings in that wherever human beings can live comfortably, the crystal element will function normally and have a very long life span. The piezoelectric limitations of Rochelle salt crystal pickup cartridges are between —40° F. and 120° F. If exposed to temperatures above 120° F., the crystal will lose its piezoelectric activity permanently. Adequate ventilation should be provided around the phonograph or radio cabinet in order that the temperature around the pickup be kept at the lowest possible value. Pickup cartridges and other crystal devices should not be stored near heaters or radiators nor should they be displayed in store windows or show cases where bright sunlight is apt to shine on them.

When leads are being soldered to the cartridge terminals during installation or service, the soldering iron should not be applied for a longer period of time than necessary to make a solid joint.

In extremely dry climates, crystal pickups have a tendency to become dehydrated (loss of natural moisture) when subjected to high temperatures. If the crystal becomes dehydrated, nothing can be done to restore it to normalcy. In climates where the temperatures and relative humidity are extremely high, crystal cartridges have a tendency to take on excess moisture.

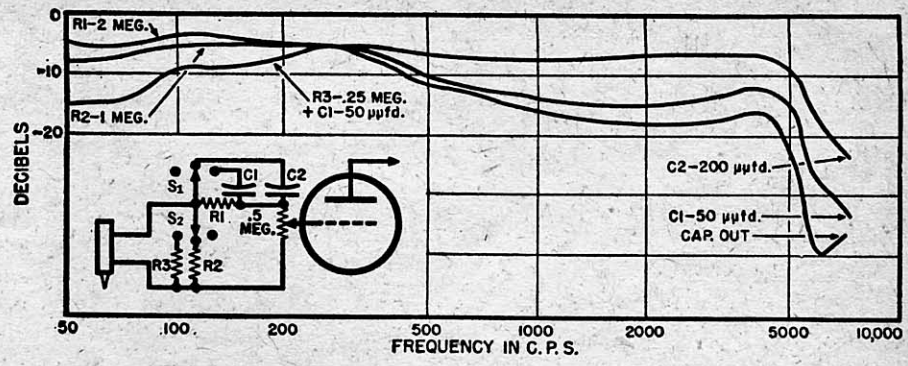


Fig. 5. High and low frequency response may be set independently with this equalizer.

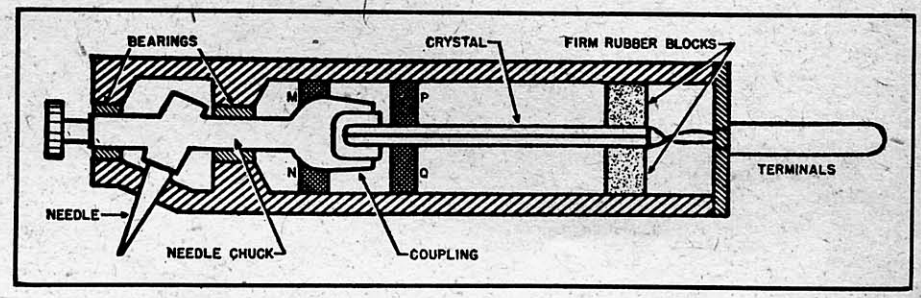


Fig. 6. Cross-section of construction details of typical cartridge employing rubber coupling between the needle and the chuck.

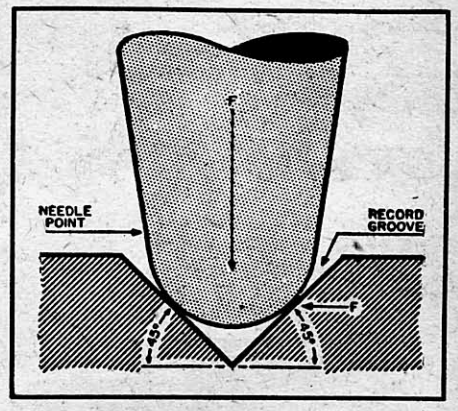


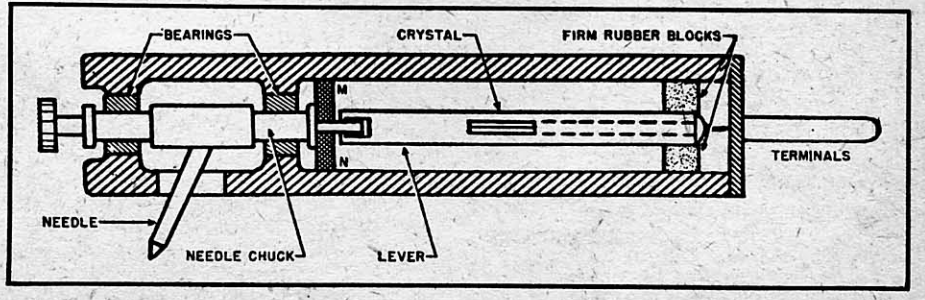
Fig. 7. Cross-sectional view of reproducing stylus in the record groove.

PN Crystal Cartridges

One of the recent developments in the crystal cartridge field is known as the "PN" which differs from the Rochelle salt crystal elements

(*Continued on page* 153)

Fig. 8. Motions of the needle chuck are transmitted to the crystal via lever action in this Shure-designed crystal cartridge.



comes from Horst Miers, (7) Berlin No. 18, Barnimstr. 8, Germany, who adds: "I presume that following the war many German special (*wehrmacht*) tubes have come to America and other countries. I can give extensive information about all German special tubes to amateurs who are interested."

* * *

Verifications

Correct address for reports to Radio Nacional de Espana is Director of Programs and Broadcasts, Aveneda del Generalisimo, 40, Madrid, Spain (Espana). This station verified in both Spanish and *English;* latter cardverie said: "Radio Nacional de Espana verifies your perfect report of reception dated 30-4-47 and sends you its kind greetings;" signed by E. Thomaas de Carranza. (Casey)

ZPA-5, 11.948, Encarnacion, Paraguay, sent nice card in red, white, and blue, with large overprint of call letters ZP-5 and ZPA-5; printed frequency on card is 11.950. PCV, Kootwijk, Netherlands, 18.070, verified on prepared form from General Direction of Postal and Telecommunication

(*Continued on page* 158)

Sound Recording

(*Continued from page* 53)

usually employed in the manufacture of phono pickups. The "PN" (primary ammonium phosphate) will temporarily stand temperatures as high as 212° F. with no permanent damage. They will withstand operating temperatures of 140° to 160° F. for a considerable time without suffering any permanent damage. Compared with the Rochelle salt crystal elements a "PN" element with the same dimensions and in the same assembly will produce a slightly higher open circuit output voltage. (Open circuit

TELEVISION COVERAGE

A RECENT FCC report has disclosed that the number of applicants for commercial television transmitting licenses has dropped from a high of 140 in October, 1945 to 75 as of June 5th this year.

The FCC has granted a total of 65 commercial television construction permits in 37 cities in 24 states. Of this number 11 stations are already on the air and 54 are required to be on the air within the next 12 to 18 months. In addition, there are ten more applications pending before the Commission—for a total of 75 commercial stations. The metropolitan population of the 37 cities to be served is around 44,000,000 with an additional 11,000,000 suburban residents within range of the stations.

The 11 stations now on the air are serving eight cities with a population of 27,000,000 persons, i.e., Albany-Schenectady, Philadelphia, Washington, St. Louis, Detroit, Chicago, and Los Angeles.

There are approximately 54,000 television receivers in the United States at the present time.

—30—

FREE! NEW Lafayette FALL FLYER

packed with spectacular bargains in Radio, PA and Ham Equipment

See the latest, greatest bargains the market offers today. Write for Lafayette's FREE Flyer C-40. It's packed to the hilt with slashing, smashing super values that have been typical of Lafayette for years. New, top quality items; speedy delivery. *Send for Flyer C-40 now and save.*

typical Lafayette super values

PORTABLE RECORD CHANGER-AMPLIFIER

MODEL JPS643

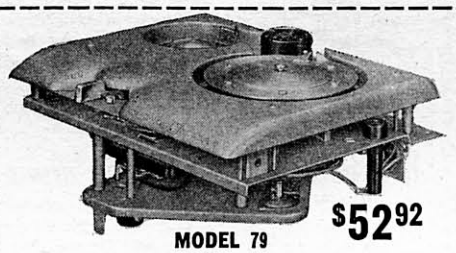


Sturdy construction; gentle action. Latest model record changer plays a stack of 10″ or 12″ records. Automatic or manual operation. Built-in amplifier uses tubes: 35Z3, 50L6, 14H7. Tone and volume controls. Alnico 5 PM speaker. Smart, 2-tone leatherette case with flexible handle and chromium fittings. 16″x19½″x9″. Shpg. wt.: 23 lbs.

$39.95

PORTABLE RECORD PLAYER.....Model JPS642

Super buy in a compact, lightweight single record player. Plays 10″ or 12″ records. The 5-inch speaker produces clear, undistorted tones; has built-in amplifier. Featherweight, tangent-pickup holds any needle. Rugged 5-ply wood case with handsome leatherette cover. 110 V. 60 cycle AC. 16½″x13″x7¼″. Shpg. wt.: 15 lbs. **$17.95**



MODEL 79 **$52.92**

WEBSTER-CHICAGO WIRE RECORDER FOUNDATION UNIT

Make your own professional wire recorder at a phenomenal saving with this now famous Webster foundation unit. This is the same model used in the Webster Portable Wire Recorder. Has complete wire transporting mechanism, a triple-purpose recording head (records, plays back and erases), an oscillator coil, a 15-minute spool of recording wire and an instruction sheet with suggested circuit diagram. The unit takes any standard Armour type recording spool; can make recordings up to full hour. 10½″x8¾″x5½″ (3½″ below main plate; 2″ above). Net wt.: 10 lbs.

Lafayette Radio
RADIO WIRE TELEVISION, INC.

100 SIXTH AVE. . . . . N. Y. 13
542 FORDHAM RD. . . BRONX 58, N. Y.
110 FEDERAL ST. . . . . BOSTON 10
24 CENTRAL AVE. . . NEWARK 2, N. J.

FILL IN COUPON AND MAIL NOW

LAFAYETTE RADIO
DEPT. RJ-7
100 Sixth Ave.
New York 13, N. Y.

Send Model No.....at once.

Enclosed ☐ Money Order ☐ Check ☐ Rush Flyer C-40

Name .....

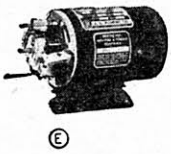
Address .....

City..... Zone..... State.....

SPECIAL SURPLUS SALE


Ⓐ


Ⓒ


Ⓔ


Ⓕ


Ⓓ

PE-73 Dynamotor **4.95**
PE-103 Dynamotor New lot, only **7.45**
Brand new, in original Signal Corps packing; delivers 160 mils at 500 volts; operates from 6 to 12 volts d-c; complete shock-mounted assembly includes breakers, switches, relays, filters, and cables.


Ⓑ


Ⓑ-A

(A) ANTENNA TUNER

A. BC. 306-A National "Velvet Vernier" dial with 100-0 scale. 5 position heavy duty high voltage—3 section RF switch. Two high voltage standoff insulators with spring type binding posts. Low frequency variocoupler. Overall dimensions approx. 18½" high, 8" wide, 8" deep **$1.66**

(B) ANTENNA RELAY UNIT

B. 0-10 Meter Weston Thermo-couple unit with 50 MMF, 5000 V Vacuum cond. (Illustrated as B-A). Complete **$2.45**

(C) RECEIVERS (274N Series)

B.C. 454A.	3-6MC	$3.95
B.C. 455A.	6-9.1MC	3.95
B.C. 453A.	190-550KC	4.95

TRANSMITTERS

B.C. 456A.	3-4MC (VFO)	$4.95
B.C. 457A.	4-5.3MC	3.95
B.C. 458A.	5-3.7MC	3.95
B.C. 459.	7-9.1MC (VFO)	7.95

EXCELLENT CONDITION

MODULATOR UNIT

B.C. 456A.	$ 3.95
S.C.R. 522 VHF XMTR-RCVR NEW.	29.75
B.C. 348 RECEIVERS Xlnt Cond...	29.95
B.C. 348 RECEIVERS New	44.95
D. Antenna Mounts, Mobile.....	.99

E. Electric Motor—110V, 60 cycle heavy duty const. Fractional H.P. ball bearing brand new. Ideal for power tools, fans and 100 other uses **$4.69**
In lots of 10..... **3.95**
F. Band Pass Filter, 1000 cycle, close tolerance..... **1.98**
Dual Choke—12 HY-200 MA 550HM D.C. resistance. Steel case with stand-off insulators. New..... **2.95**

Also thousands of additional special items such as condensers, tubes, capacitors, transformers, insulators, radar equipment. Inquiries solicited. Get your name on our mailing list. Terms: 33⅓% with order. Balance C.O.D.

ESEGE SALES, Ltd.
1306 Bond Street
LOS ANGELES, CALIF.

NOW—IMMEDIATE DELIVERY

TRANSVISION

New—Sensational
12 Inch Television Kit
Picture large enough for 60 or more people.



$289

***PRICE* (Complete, less cabinet)**
Deposit of $25 required. Will ship COD for the balance.

Includes FM sound, 23 tubes including 12 inch picture tube, folded dipole antennae and 60 ft. lead-in wire. Nothing else to buy. All complex units pre-assembled at the factory and fully guaranteed for 90 days. Complete step-by-step wiring instructions, including pictures and wiring diagrams. Absolutely no instruments or technical knowledge required. All you need are pliers, screwdriver and soldering iron.

Beautiful Walnut Table Model Cabinet. **$44.95**
Beautiful Console Cabinet, with provisions for Record Changer and 12-inch Speaker **74.50**
Plastic Lens for enlarging 7-inch or 10-inch pictures to 12-inch..... **49.50**
Adaptor for above lens..... **3.25**

Write for Special Dealers' Discount

NATIONAL RADIO DISTRIBUTORS
899a Southern Blvd., N. Y. 59, N. Y.

Ever Sit On A Gold Mine?



YOU can build a business of your own NOW — either part or full time — with TRADIO, the radio functionally designed for coin-operation in hotels, motels, stopovers, hospitals, etc. Big earnings . . . Steady income . . . and no clock to punch unless you want to.

★ ONLY SMALL INVESTMENT NEEDED

Tradio has pioneered in this new and fast growing industry. Get in on the ground floor and assure yourself of financial independence for life.

★ TRADIO IS TRIED, TESTED and PROVEN

Thousands of others all over the country have learned that "Tradio Pays While It Plays." Send for complete information today.-



Write To Dept. P-10

TRADIO, Inc. ASBURY PARK NEW JERSEY

means no load resistance, cable capacitance, or other impedances connected to the element.)

The capacitance of a typical Rochelle salt crystal cartridge element is approximately 1500 $\mu\mu$fd., while that of a "PN" element having the same dimensions is about $\frac{1}{10}$th this value. Because of this comparatively low capacitance, a "PN" type cartridge cannot be used to replace a Rochelle salt type crystal cartridge directly for two reasons: 1. The additional capacitance of the cable or wire connected to the cartridge causes considerable loss of output. 2. The lower capacitance of a "PN" element requires that the load resistance used in pickup applications be approximately ten times the value used with a corresponding Rochelle salt unit if it is desired to obtain the same frequency response. This means values of from 5 to 50 megohms. When these high values of resistance are used at the input of a high gain amplifier, difficulties with insulation and noise pickup are much more severe than with the conventional low values. Certain manufacturers have employed "PN" crystal cartridges with equipment especially designed for their use.[1]

We mentioned previously that there were many varieties and versions of the crystal type pickup. In any pickup the torsional motion of the needle is transmitted to the crystal through a needle chuck. The needle is quite brittle and torsionally stiff. Therefore, if the needle were connected directly to the crystal, the pickup would present a high needle point impedance to the record. This would result in poor tracking and high record wear. For proper performance, the torsional stiffness of the crystal must be decreased by a ratio of roughly 25:1. Previously this has been done by interposing an elastic rubber block between the needle chuck and the crystal. The pickup cartridge, shown in cross section, Fig. 6, typifies this construction. The crystal is held at its lead end by means of two firm rubber blocks. At the front end the crystal is coupled to the needle chuck by means of a soft rubber coupling. Torsional motions of the needle compress the rubber coupling. The pressure thus developed acts upon the crystal and produces an output voltage proportional to the pressure.

The record groove is capable of transmitting only a limited torque to the needle chuck. This can be seen by examination of Figs. 1 and 7. This shows the groove and the needle point in cross section. The walls of the groove are inclined at approximately 45°. Therefore, the side force upon the needle point cannot exceed the vertical pickup force, otherwise the needle rides "uphill," resulting in distortion and record wear. Torque is force times distance. The maximum theoretical torque, T_m which can be applied by the record to the needle

[1] Poff, J. K.; "The Crystal Phonograph Reproducer—Its Application and Care." Service Engineer, The Astatic Corporation, Conneaut, Ohio.

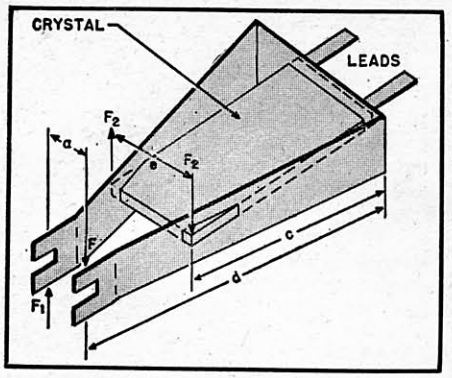


Fig. 9. An isometric drawing of the lever system design.

chuck of a pickup is given by the following formula:

$T_m = Fh$ *dynes-cm*.....(1)

Where: F is the vertical pickup force in dynes; h is the vertical distance from needle to needle chuck axis in cm.

The maximum torque is, therefore, limited by the needle force and by the length of the needle which, because of practical considerations, cannot exceed ½ to ¾ of an inch. The actual torque is considerably less than the value indicated by (1). Because of unevenness of records, turntables, and the inertia effects of the tone arm, a part of the torque actually generated is lost in the needle chuck areas. In a conventional pickup, what remains of the original torque is transmitted into the rubber coupling in the crystal. The potential energy due to this torque is divided between the crystal and the rubber coupling in proportion to their respective compliances.

Inasmuch as the coupling compliance is related to the crystal compliance by a ratio of 25:1, it is seen that 25/26ths of the energy received from the record is spent in compressing the rubber coupling and is wasted. The remaining 1/26th is actually applied to the crystal. If means are employed for more efficient transmission of energy into the crystal, the output voltage may be increased theoretically by the square root of the energy ratio or approximately 5 to 1. This indicates the desirability of eliminating the elastic rubber coupling. But if the elastic coupling is eliminated, the impedance presented by the crystal to the needle is too great for proper tracking. To remedy this it is necessary to resort to an impedance matching device. Transformers for electrical matching are well-known to radio engineers. However, in mechanics, the lever plays the counterpart of an electrical transformer.

In the new pickup described here and developed by *Shure Brothers,* a torsional lever system was developed to lower the needle point impedance and to efficiently transmit the needle chuck torque into the crystal.

Lever Type Pickup

The new pickup developed by *Shure* is illustrated in cross section in Fig. 8. Fig. 9 shows an isometric drawing of

Whether

RADIO AMPLIFIER or QUANTOMETER



PHOTO COURTESY RADIO STATION WOR & WESTERN ELECTRIC

Cannon Electric Type DPB Connector using gold-plated contacts in Studio Control Booth Console, Type 120 Amplifier in the low level side. Plug-in connector greatly increases ease of servicing and maintenance.

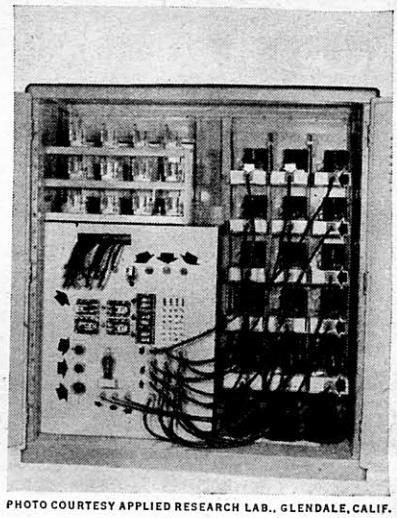


PHOTO COURTESY APPLIED RESEARCH LAB., GLENDALE, CALIF.

Arrows point to Cannon Electric Type "K" fittings connecting a maze of circuits on the Quantometer, a direct-reading spectometer which determines chemical analysis of metals in 45 seconds. Rear view shown.

Plug-in with

CANNON PLUGS



K-21 Plug



RK-24C Plug

TYPE "K"—made in 3 general shell types with nearly 190 insert arrangements available for a wide variety of wire sizes, including coaxials.



TYPE DPB—rack type pin and socket assemblies (both for fixed mounting) carry standard, coaxial and twinax contacts. Six basic layouts available in DPB, many more in the larger DPD shell size.



NEW EDITION C-46-A CATALOG—For a complete survey of the majority of Cannon Electric products, send for this C-46-A Catalog, containing prices on many items. Also included are the names and addresses of our distributors. Write Department J-228.

CANNON ELECTRIC

CANNON ELECTRIC DEVELOPMENT COMPANY

3209 Humboldt Street, Los Angeles 31, California

Canada & British Empire—Cannon Electric Co., Ltd., Toronto, Ontario • World Export Agents (excepting British Empire) Frazar & Hansen, 301 Clay St., San Francisco 11, Calif.

RADIO-ELECTRONIC SCOOPS from MID-AMERICA

Order by Mail While Limited Quantities Last!

Listed here are a few of the hundreds and hundreds of radio and electronic bargains Mid-America has to offer right now! Order direct from this ad for quick delivery, and ask for Mid-America's great, new catalog that lists many other big buys just like these!

274N-TYPE TRANSMITTERS
Complete with Crystals and All 4 Tubes

Transmitters in this series have a 1626 temperature-compensated oscillator circuit, two 1625's in parallel as RF power amplifiers, and a 1629 resonance indicator for the crystal calibration circuit. These units were designed for voice, MCW and CW transmission.
4.0-5.3 MC. Used but in good condition.
4500 KC crystal. MA-2120.....$3.95 ea.
2.0-3.0 MC. Brand new units. 2500 KC crystal. MA-2121 ..... 4.95 ea.
3.0-4.0 MC. Used but in good condition.
3500 KC crystal. MA-2122..... 3.95 ea.

SPECIAL! Antenna Assembly AN-104-B

Used with SCR-522, 274-N, and ARC-5. Approximately ¼ wave on 100-156 MC. Coaxial connector in base. Use anywhere; has silver weather-proof finish. Two of these make an excellent dipole for FM or television; large cross-sectional spacing permits broader than usual band tuning.
MA-2153 .....Ea. **79c**

GREAT PARTS VALUE! Brand new APA-1 radar indicating equipment. Amplifier contains 11 tubes: 2x2/879, 6H6, 6G6G, 6X5GT, 7-6SN7GT. Chassis loaded with resistors, condensers, etc., contained in handsome metal cabinet. Control unit in separate cabinet has switches, potentiometers, connectors, etc. Scope indicator with 3BP1 CR-tube enclosed in metal shield; has rubber-tipped visor and 6 feet of 11-conductor shielded cable. All new, with tubes and operating handbook. MA-2123 **$19.95**

SPARE PARTS CHEST—53 popular tubes, hundreds of resistors and condensers, transformers and chokes, wired amplifier with 115 V, 60 Cy power supply, plugs, switches, connectors, cables, hardware, sockets, etc. Hardwood cabinet 30½x30½x32½ with storage compartments and 5 20" drawers makes excellent workbase. MA-2096..... **$49.50**

MARKER BEACON RECEIVER BC-1023-A—with tubes (6SQ7, 6U6GT, 6SC7, 12SH7). 12-14 VDC input. MA-2107.....Ea. **$4.45**

SCR-518 ABSOLUTE ALTIMETER—Complete equipment with tubes, power supply, scope indicator, etc. MA-2106.....Ea. **$49.50**

TUBULAR ELECTROLYTIC CONDENSERS

	mfd	WVDC	EA.
MA-829	50/30	150	79c
MA-831	8	450	29c
MA-832	16	450	45c
MA-833	8/8	450	45c
MA-835	20	25	29c
MA-836	40	150	49c
MA-838	150	25	39c
MA-115	100	15	19c

PLATE-MOUNTING METAL-CASED FP CONDENSERS

	mfd	WVDC	EA.
MA-826	8	250	49c
MA-442	16	500	89c
MA-806	25	25	29c
MA-837	40/40/30	150	98c
MA-443	125	300	98c

ORDER NOW! Send 25% deposit with orders. Order by stock number. We ship fastest possible way C.O.D. for balance and shipping charges. Send orders to Mid-America's store address. Address orders to Desk E-107.

FREE CATALOG

Rush your name and address for Mid-America's great new catalog that lists thousands of items at prices that defy competition. Get your name on our mailing list for monthly bulletins that keep you up-to-date on the latest bargains in top-quality radio parts, and electronic equipment. Address requests to Desk E-107.

MID-AMERICA CO. Inc.

STORE 2412 S. MICHIGAN AVE. CHICAGO 16, ILL.
WAREHOUSE 2307 S. ARCHER AVE. CHICAGO 16, ILL.

the lever system. The lever consists of a single strip of thin aluminum perforated to receive the crystal and bent in a trapezoidal shape. The rear portion of the lever and crystal assembly is held in the cartridge case between two firm rubber blocks. The ends of the lever engage the needle chuck through two composition pads which serve to provide longitudinal shock isolation between the chuck and the lever but have negligible transverse compliance. For all intents and purposes, the motions of the needle chuck are faithfully followed by the ends of the lever. This particular type of lever pickup has an important structural advantage over most conventional pickups because it does not depend upon soft rubber couplings, or other materials which deteriorate with age, for generation of voltage.

The structure of the lever pickup is dynamically simple. Since the lever is rigidly coupled to the needle chuck, the system has only one degree of freedom and can be damped therefore, with a single set of damping pads, *M* and *N* in Fig. 8. In contrast to this, the conventional pickup (Fig. 6) has two degrees of freedom; the needle chuck and the crystal which are loosely coupled by the rubber coupling member. Two separate sets of damping pads *MN* and *PQ* are therefore required. The selection and control of two sets of damping pads has made it difficult to control such pickups in production. In the design of the lever type pickup, care is taken to hold the lateral mass referred to the needle point to a very low value. The needle chuck is made of a very light alloy. When used with an aluminum shank needle, it presents to the record a mass of less than 50 milligrams. Tests on frequency records with needle forces of one ounce indicate good tracking at all frequencies.

(To be continued)

GERMAN HOME RADIO RECEIVER

BY KARL GREIF

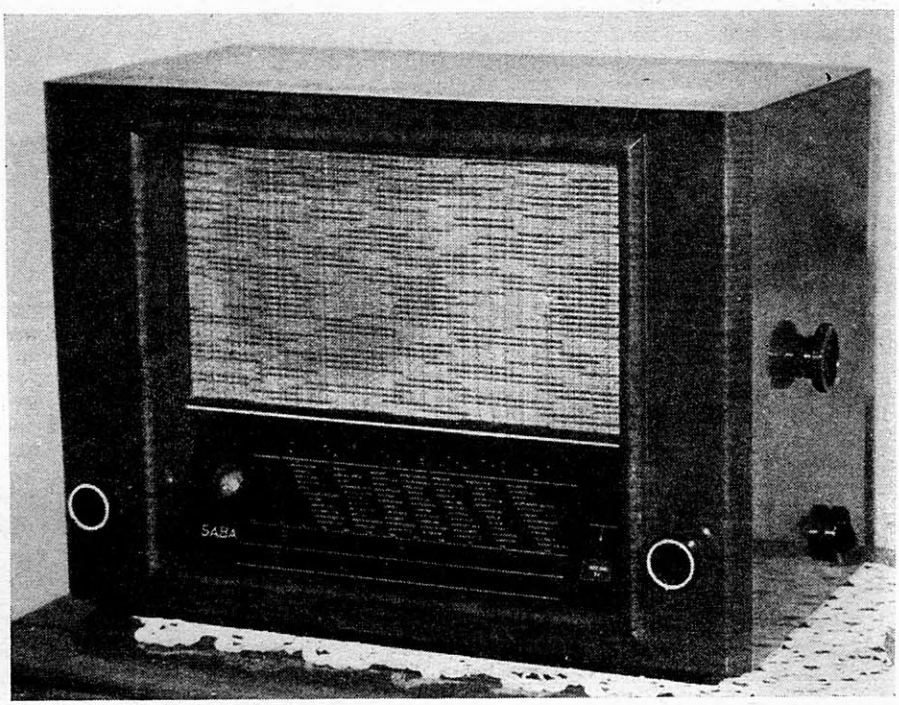
A NEW radio receiver of German manufacture which is being marketed under the tradename "Saba" has several new features which are of interest to the radio industry.

The receiver features an enormous slide-rule dial, with the names of cities located in such a manner that when the pointer is in a certain marked rectangle on the dial, that city is "in tune". This feature is in addition to the regular calibration in kilocycles and meters.

Tuning is accomplished with a very heavy fly-wheel, high ratio cable, and pulley system. The tuning knob is at the right end, as well as the band switching control. Possible selections included "Phono," "150-400 kc.," "500-1500 kc.," "30-92 meters" and "13.5-36 meters." At the left of the front panel is located the "on-off" and volume control—pulling out on this knob turns the set on with any 50-60 cycle voltage from 110 to 220 volts, in steps. The other knob on the front, at the right, is for tone control. Dual range is provided by pulling out on this knob.

The circuit is very selective and extremely sensitive. Forty-two clear stations have been logged without advancing the volume above local station level. Background noise is at an absolute minimum. The set uses a separate i.f. resonant circuit for each band. —30—

Product of a German company, this "Saba" home receiver could be classed as "above average" in the European market. The usual type of receiver manufactured on the Continent is of the two- or three-tube regenerative variety.



The RECORDING and REPRODUCTION of SOUND

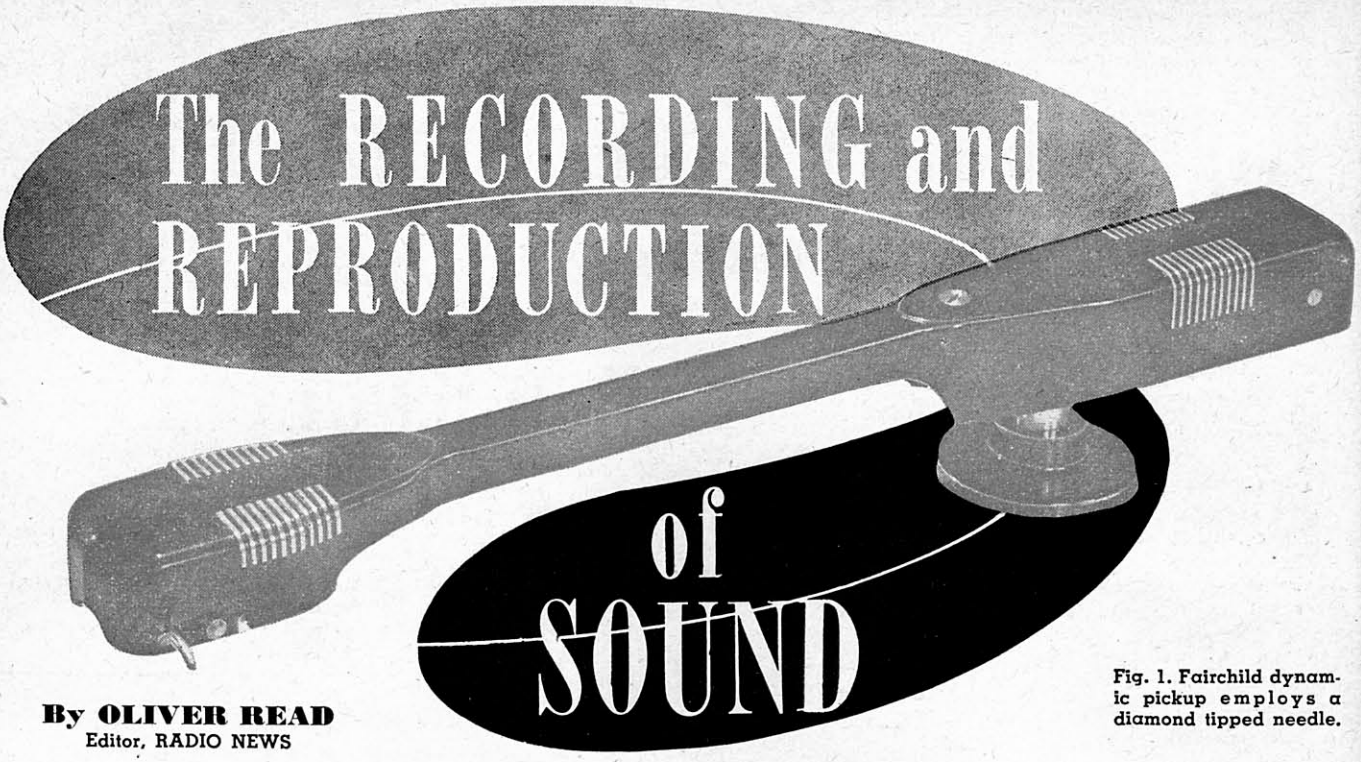


Fig. 1. Fairchild dynamic pickup employs a diamond tipped needle.

By OLIVER READ
Editor, RADIO NEWS

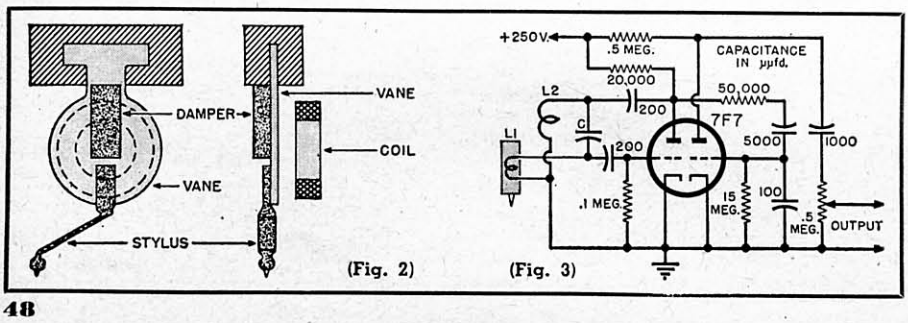
Part 9. Magnetic reproducers—miscellaneous phono pickups comprise many types and varieties. These include magnetic, dynamic, moving vane, ribbon, etc.

THE very earliest types of *magnetic* pickups employed a heavy weight which exerted considerable pressure on the record during reproduction. These often used as much as six or seven ounces of pressure for the needle to track properly and to keep the needle in constant contact with the groove.

As far as the springiness of the needle system is concerned, we must consider the weight of the needle and all of the other moving parts which combine to produce the "needle impedance." If we are to get maximum response, lowest record wear, and good, clean tone quality, these factors must be carefully considered by the manufacturer. Therefore, it is necessary that low needle impedance be maintained. The needle impedance in the modern pickup is kept to a very low value, hence, it is possible to acquire almost ideal reproduction.

Probably the best analogy for magnetic pickup is the generator as used in our large electrical power plants. Here we find that a wire is moved in the vicinity of a magnet. This creates a current of electricity in the wire or, conversely, the magnet may be moved and the wire fixed in a stationary position. The earliest magnetic pickups were also known as "moving iron." These had a stationary coil of wire, a magnet, and an armature which was attached to the needle. The armature moved with the needle inasmuch as it held it stationary in place. This, in effect, shifted the magnet with respect to the coil and created electrical impulses in the coil. This variable current was then amplified in the form of sound.

Fig. 2. Moving vane structure of Zenith "Cobra" pickup. Fig. 3. Movement of pickup stylus amplitude-modulates an oscillating detector amplifier. Audio signal is obtained at output.



(Fig. 2) (Fig. 3)

The modern broadcast station, especially those employing FM, use very expensive and precision made *moving coil* type pickups or variations of magnetic units. These units use a very small needle pressure and record life is greatly increased due to the low pressure of the needle as it rides in the groove. It should be pointed out, however, that there is a minimum weight requirement for any pickup. First of all, too little pressure will cause the needle to "ride up" on one wall of the groove and distortion will take place. Secondly, on a fast whirling disc, the tendency for the needle to "ride out" on the disc will cause the pickup to actually slide across the record without engaging the bottom, or even the wall, of the groove.

One of the most important characteristics that affects record wear and tone quality is the resistance of the needle system to side motion. This is known as "needle impedance." In any pickup it is not possible for the needle itself, or the armature which connects thereto, to move freely in space. Any driving system has a certain amount of spring to it. In addition to this springing action of the needle system, we must consider the weight of the needle itself which strongly resists vibration in the groove.

The inertia presented to a phonograph needle as it is pushed from side to side in the groove at rates to 8000 c.p.s. or even higher, suddenly becomes a very large force working against the record groove.

In the moving coil type of pickup, the magnet is stationary and a tiny coil is attached to the needle in such a manner that it vibrates in cadence with it. This principle is used in many of the finest pickups available today.

They are widely used in broadcast stations as previously mentioned. However, due to their high cost and precise manufacturing methods, they are too expensive to be employed in the average home phonograph.

The FM Pickup (Frequency Modulation)

In previous chapters we described and showed accompanying diagrams for the earliest type of FM or "condenser type" pickup. Actually, modern systems employ very small FM transmitters in the system. The condenser plates, of which there are two, in the pickup are mounted in very close proximity to one another. One of these plates is attached directly to the needle. The two condenser plates are electrically connected to the circuit of the miniature FM transmitter. The needle vibrating in the groove also causes one of the plates to move in direct relationship to the lateral swing of the needle. By varying the oscillator or transmitter capacitance, electrical impulses corresponding to the motions of the needle are transmitted through the system.

The Strain Gauge Pickup

The strain gauge pickup was designed originally for commercial applications. It is still widely used in industry to measure the bending of steel girders, etc. In this pickup a small piece of special wire is stretched between two points on the surface of an object. A current of electricity is passed through the wire and registers the small changes in the amount of stretching of the wire.

In the strain gauge pickup, for phono reproduction, the wire is stretched across and in front of the pickup head and the needle is connected to the middle of it by a lever system. As the needle moves, the wire is stretched alternately one way and then the other. This takes place in perfect cadence with the needle motion. The resulting electrical current, which is variable, is then passed on to the amplifier.

The Zenith Radionic Pickup

Similar to the FM or condenser type of pickup is the "Cobra" pickup (Fig. 2) designed by *Zenith* engineers. This, however, operates on AM principles. A round flat vane is attached to the top of the needle and a small coil of wire placed next to the vane. This coil is connected electrically to an oscillator (Fig. 3). As the vane vibrates in cadence with the needle, it produces a change in the action of the coil. As a result, the oscillator produces a corresponding electrical change. These impulses or changes are then passed on to the amplifying system. This type of pickup is illustrated in Fig. 4.

In the *Zenith* pickup we find that the mechanical impedance is extremely low. In fact, not more than about fourteen grams weight is necessary for proper tracking on the record which makes long record life possible as there is little wear to the groove.

The high resistance vane of the pickup stylus moves in direct relation to the inductance of the resonant circuit of the r.f. oscillator. By varying the mutual inductance between the coil and the vane, the resistance reflected into the coil changes. By so doing, amplitude modulation is produced in the oscillator by varying the loss of the resonant circuit. It is necessary then to detect the variable r.f. currents and to pass them on to the amplifier.

Tests show that a vertical weight of approximately ten grams is required to keep the needle in the groove. The mechanical impedance together with the vertical compliance reduce the noise that is radiated from the pickup and record to the extent that it is hardly noticeable to the average human ear. This applies even when the pickup arm and assembly is uncovered.

This type of reproducer can also be made to operate as a push-pull pickup. To do this, two identical coils are arranged at either side of the high resistance vane and both are tuned to the same frequency. The two circuits are then coupled either by their stray field or by external means.

The Tuned-Ribbon Pickup

A recent contribution to high quality reproduction, especially of soft and pliable discs, is the tuned-ribbon pickup developed by Maxmillian Weil and manufactured by the *Audak Company*.

A novel carrier structure, from which the oscillating member is suspended, is the heart of the system. This is shown in Fig. 5 which illustrates the principle of operation of the vibrating system. As can be noted, the stylus displacement imparts a rotational motion around the axis of a horizontal member. This horizontal member, known as a "limiter," is located just above the stylus and between two horizontal metallic ribbons (Fig. 6), which are approximately .002 inch in thickness. They are securely anchored at points *A* and *E* (Fig. 5). At the other end of the limiter is a universal ball and socket bearing. The ends of the ribbons are carefully welded to a magnesium limiter shaft. These are located at opposite ends of the exact diameter of the shaft.

This design allows the limiter to rotate freely providing the ends of the ribbons attached to it can also move in substantially parallel paths or, in other words, for a displacement of the ends of the ribbons in the order of a few mils. As the ends of the ribbons start to move in arcs away from each other, greater displacements occur and the rotation of the limiter accompanying it. Then the motion of the stylus is stopped. By allowing the stylus to move with complete freedom, a distance of approximately .002 inch each side of the center portion is attained, or far more than enough to take care of the widest amplitude to be expected on disc records. Of great importance, the stylus displacement having been reached, the system will then lock itself against further motion. The stylus

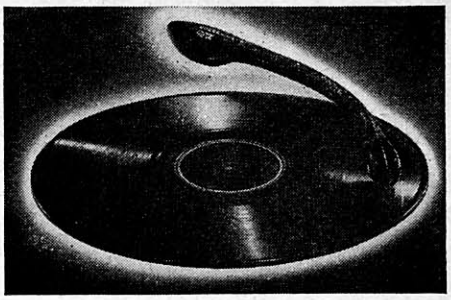


Fig. 4. Offset tone arm houses the "Cobra" pickup cartridge.

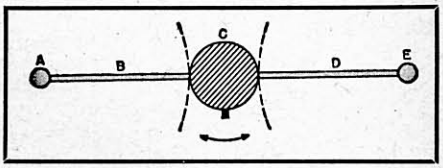


Fig. 5. Simplified diagram of Audak tuned-ribbon pickup. (A) and (E) are anchor points, (B) and (D) are tuned-ribbons and (C) is the stylus support.

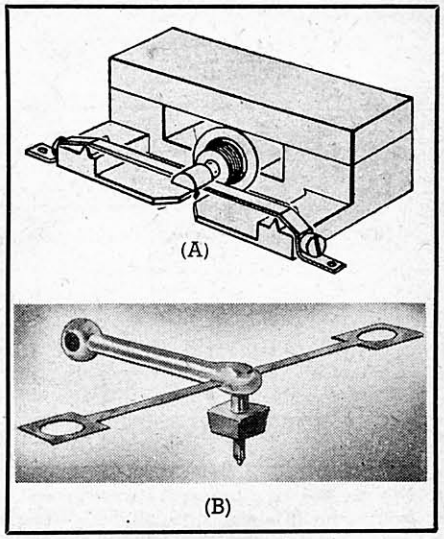
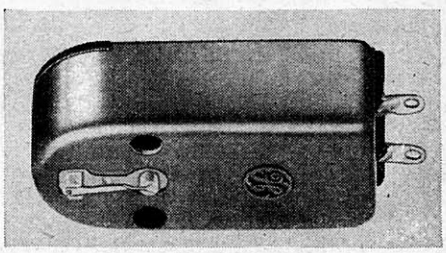


Fig. 6. (A) Armature and magnet assembly of Audak tuned-ribbon pickup. A bar type field magnet is used. (B) Artist's sketch shows over-all view of pickup.

is also permitted to move freely in a vertical direction for approximately the same distance as it moves laterally. Therefore, this type of pickup may be used on either vertical or laterally cut records. Accordingly, turntable equipment which is to be used in conjunction with the above pickup must be free from mechanical vibration either in a horizontal or in a vertical plane. Great care must be

Fig. 7. The G.E. variable reluctance pickup.



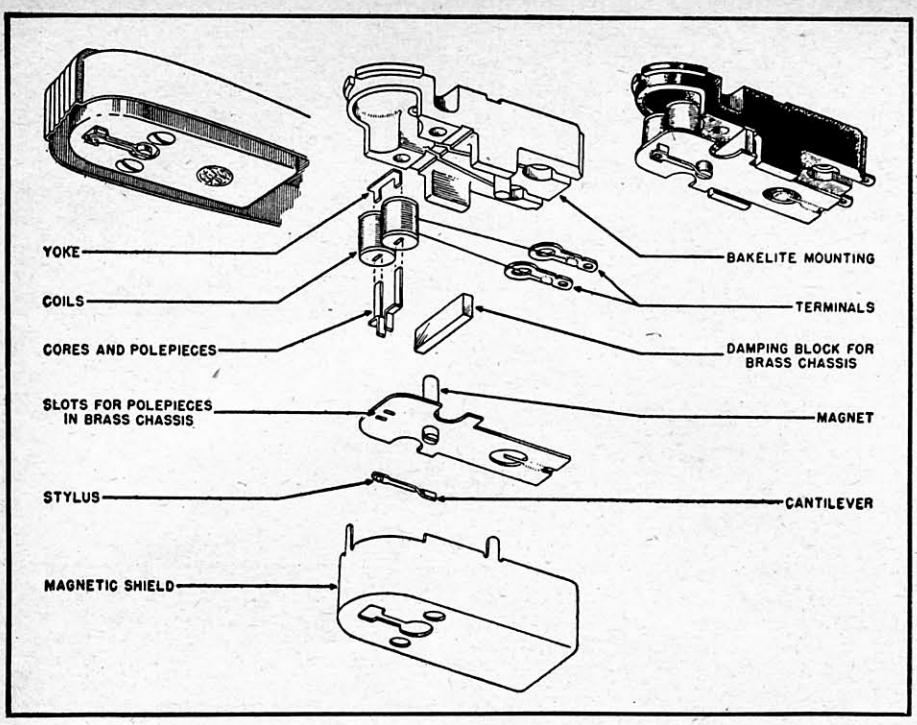


Fig. 8. Exploded diagram shows the construction of the G.E. variable reluctance pickup and the assembly of the various components used.

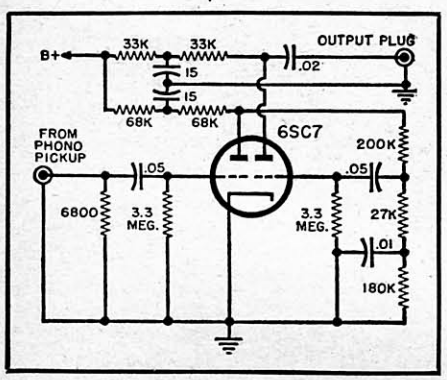


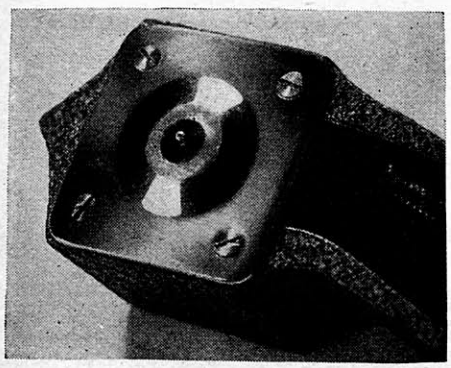
Fig. 9. Pre-amplifier and equalizing circuit used in conjunction with the General Electric variable reluctance pickup. Like extremely high fidelity microphones, this reproducer's output voltage is low.

exercised to anchor the turntable mounting board firmly against any undue vibration which may be transmitted by the motor through the idler pulleys or belts.

One of the features of this assembly is that the dynamic mass of the system is at the truly remarkable low value of only 4.43 milligrams. A reduction in the requirement for stylus pressure, which results from this near-elimination of vibratory mass, permits the pickup to operate with a pressure of approximately ten to fifteen grams. Included, therefore, is a wide safety margin which covers every possible type of groove modulation, the degree of warping, turntable rumble, etc. Under favorable conditions, and assuming that the table were perfectly level, this pickup would track with approximately half the above pressures. This, however, would not be recommended for general use on commercial records.

This type of pickup, due to the near zero mass of the vibrating system, produces a frequency characteristic that is approximately a straight line to about 11,000 cycles. This is more than is needed for the majority of transcriptions.

Fig. 10. The Pickering pickup. A linear response characteristic from 30-15,000 cycles-per-second may be obtained with this unit.



The Variable Reluctance Pickup

One of the simplest and most efficient pickups designed in recent years is the *General Electric* variable reluctance pickup. A natural sapphire stylus is mounted on the end of a small cantilever spring, as indicated in Fig. 7. The lateral motion of the cantilever directs the magnetic flux alternately through the cores of two coils which are connected in push-pull. The exploded view, shown in Fig 8, illustrates the mechanical design of the pickup. Note that a slotted bushing is provided in the brass chassis. The end of the cantilever spring away from the stylus is soldered to the top side of this non-magnetic bushing. A cylindrical Alnico V magnet is soldered to the underside. Pole pieces made of Mu metal extend through the two coil cores and project on each side of the front end of the cantilever which carries the sapphire stylus.

As the stylus is driven laterally in the record groove, the cantilever moves correspondingly with respect to the pole pieces. The flux from the magnet passes through the bushing and the cantilever spring and across the small air gaps to the pole pieces, so that it divides equally between them, providing the stylus is centered. At the opposite end the cores are joined by Mu metal yokes. The flux passes from these through the air to the other pole of the magnet. As the cantilever moves off center, the flux increases through one coil and decreases proportionately through the other. The output voltage generated in the coils is directly proportional to the rate of change of flux. Thus, the pickup responds accurately to a constant velocity signal but requires equalization in a constant amplitude region.

The output voltage from the average record is approximately 11 millivolts at 1000 c.p.s. Therefore, a gain of approximately 40 db. at 1000 c.p.s. is needed for a preamplifier and equalizer (Fig. 9) to make the output compare with the average crystal pickup.

An extremely low needle scratch results with this pickup due to the fact that the device responds only to vibrations in a lateral direction. By eliminating the resonant response in the unit's design, low distortion and low needle talk is provided. Since the output voltage is generated directly by the motion of the stylus mounting structure, there are no losses or long coupling members.

The extremely small mass permits excellent high frequency response. Vertical motion of the stylus is equal with respect to the pole pieces and there is no voltage generated by vertical components. This, combined with the damping effect of the high vertical spring compliance, contributes a great deal to the clean quality of the response by eliminating, to a great degree, the effects of pinching distortion. Then too, the lack of vertical response also eliminates a considerable portion of the frictional noises which ordinarily are transmitted from the record surface.

The pickup chassis is coupled to the bakelite base through a single wire which is supported in the rear and by a viscaloid damping block. Hence, practically all effects of arm and supporting structure resonances are eliminated. A torsional resonant period at 10 kc. in the cantilever spring is damped out with a special viscaloid damping block. Harmonic distortion is very low in this type of pickup. It is further reduced by the use of push-pull connections.

The Pickering Pickup

Another simple and effective pickup is illustrated in Figs. 10 and 11. A

(*Continued on page* 160)

SENSATIONAL SURPLUS SALE!

$351.00 VALUE



13 tubes for the above unit plus a 200 Kc crystal. Regular $.0.00 value. Your cost $..95.

Outstanding Transmitter-Receiver Buy Famous BC-654

Precision Built . . . 13 Tubes

You will want this amazing and versatile unit. Just follow these features and see why the BC-654 has us excited:
√ 7 tube superhet receiver. √ 6 tube transmitter. √ puts out 25 watts on CW. √ 3300 to 5800 Kc. √ receiver has 3.5 microvolt sensitivity on voice, 0.5 microvolt sensitivity on CW, and 100 milliwatts undistorted power ouput. √ receiver uses 3-1N5GT, 1-1A7GT, 2-3Q5GT, 1-1H5GT; has 455 Kc. I-F. √ transmitter has antenna tuning network. Colpitts thermal compensated oscillator, class C final (2-307A tubes in parallel). √ crystal oscillator for frequency check every 200 Kc. 11.2 watts voice output.
This unit makes an ideal portable set—with combined features of voice and CW transmitter as well as a receiver in good condition.

$7.95

NAVY COMPARTMENT SPEAKER AMPLIFIER UNIT With Heavy Duty Speaker (32 oz.)

Speaker alone worth $25.00



Works from 110 volts AC-DC. Used but in operating condition. Uses 1-35Z5 Rect. & 2-35L6 in P.P. Audio input .006 watts 600 ohms imp. 5 Channel selection input, volume control complete with tubes in gray navy case 14x14x7½" for wall mounting.

YOUR PRICE **$9.95**

VALUE $100.00

U.S.N. MODEL 6 TUBE SHIP RECEIVER—MODEL RAK-5



YOUR PRICE **$29.95** Complete with tubes

The ideal commercial receiver for experimenters, hams, aviation, marine, etc.
Two tuned RF stages—band switching panel—DB meter, AVC level control antenna and RF controls—audio tuning control—sensitivity controls including an AC-DC filament voltmeter with range of 10 volts. Frequency Range covers 15KC-600KC. Value $350.00.

All Prices F.O.B. N.Y.C.—20% deposit, balance C.O.D.

MANUEL KLEIN

74 CORTLANDT STREET NEW YORK 7, N. Y.



THIS IS THE BUSINESS YOU DREAM ABOUT

QUICK, STEADY PROFITS

CORADIO

The Coin Operated Radio

Every day more and more men and women are going into the fabulous coin operated radio business. It's new, fast-growing depression proof. Coin operated radios are placed in hotels, tourist courts, clubs, hospitals, etc. on a commission basis... plays 1 or 2 hours for 25c and produces immediate profits. You continue to draw your profits every single month for years to come.

The best and most popular coin operated radio is the CORADIO.

ACT NOW

Here is a golden opportunity to start your own business, full or part time. Be your own boss at your own hours.

Send for Free Illustrated Catalogue and Complete Information

***WRITE TODAY*—Dept. R.N.**

CORADIO

COIN OPERATED RADIO
108 W. 31st ST. N.Y. 1, N.Y. WISCONSIN 7-5902

NOVEMBER SPECIAL

OPERATES FROM A BEAM OF LIGHT

Photo-electric relay kit complete with all parts including tubes, relay, sensitivity control and simple assembly instructions. Build your own magic eye alarm system—use light beam control.

Your cost only $4.95

LABS — SCHOOLS — INDUSTRIALS — GET ON OUR MAILING LIST—SEND US YOUR REQUIREMENTS.

Allied Relay 3 pole d.t. ceramic insulation 10 amp. contacts 115V. 60 cycle..... $2.50
Leach 6V DC 3 pole norm. open. #1024.... 1.25
GE 110V DC, S.P.D.T., 10,000 ohms resist., operates on 8 mills..... .75
Allied 24V DC, D.P.D.T., 10 amp contacts .40; 3 for..... 1.00

G.E. Solenoid operated contactor #CR28..0—controls 6 circuits—operates on 115V, 60CY., 4¾x9¾. 15 amps contacts double break each circuit, G.E. Catalog price $25.00. YOUR PRICE... $4.95

U.T.C. "S-6" input Xtmr-line or mike to grid; Dealer's price $3.10. Your cost..... $1.25
Sprague metal can capacitor noninductive—1.2mfd. @ 600V; 6 for..... 1.00
Mica Capacitor—0.4 mfd @ 600V—Cornell Dubilier—ideal for standards. Your cost only .95

Weston #476—3½" Bakelite; .0-8V AC. $3.95
Weston #507 R.F., amps. .0-1.5 2% accuracy to 65mc; bakelite case..... 3.95
GE 0-15V DC, 2½" bakelite case..... 2.95
GE 0-15V AC 800 cycles bakelite case, 2½"..... 2.50

Westinghouse Filter chokes—4 hy @ 90 mills, 300 ohms res. hermetically sealed 2" can .69; 5 for..... $ 3.00
5 pole, on & off rotary switch with knob; 10 amps. @ 120V Mfg. Arrow H&H .59; 10 for..... 5.00
Selenium Rectifiers—36 volts @ 300ma. full wave bridge..... 1.25
115V @ 10ma. miniature type full wave bridge..... .49
Five Tube Superhet Kit, Attractive bakelite cabinet (9x6x5) & complete parts for 5 tube superhet, using 50L6, 35Z5, 12SA7, 12SQ7 and 12SK7 (less tubes)..... 10.45

3" Vibrating Bell, 115V, 60 cyc. Rugged Construction. SPECIAL... $1.25

25% deposit with order; balance COD; save COD charges; send full amount.

RADIO DEVELOPMENT & SALES CO.
382 State Street Brooklyn 2, N. Y.

very light, stiff tube is suspended between pole pieces by a cantilever spring. The sapphire stylus is held in an aluminum mounting which is spun into the tube. The mass of the stylus and mounting is approximately .008 grams. The moment of inertia of the entire moving system (referred to the stylus tip) is 11.6 milligrams and the stiffness approximates 1.8 x 10^6 dynes per centimeter. Resonance between the lateral stiffness and the mass of the arm appears at the sub-audio frequency of 10.5 cycles per second. The restoring force against vertical displacement of the stylus is supplied solely by the cantilever spring and the vertical stiffness is made higher in order to prevent the stylus from losing contact with the groove at higher frequencies.

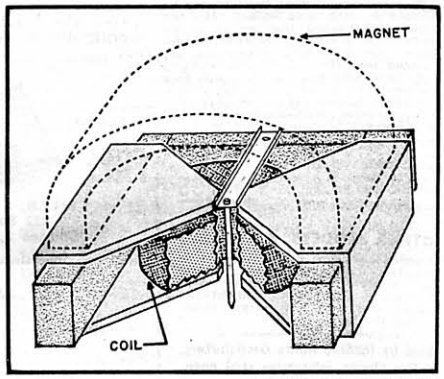
In 16 inch models the spherical radius of the stylus tip has been determined as optimum at .0025 inch for the playing of lateral transcriptions. On the other hand, 12 inch arms are used largely on shellac records. Therefore, the stylus radius is made slightly larger or approximately .003 inch. This is necessary in order to decrease the surface noise and to further decrease tendencies on the part of the pickup to rattle.

The suspension of the armature allows vertical compliance of the stylus in order to minimize record wear and to provide accurate tracking on warped records. However, vertical motion, due to the unique electrical arrangement, does not induce voltages in the coil. This arrangement also provides protection for the stylus against any abrupt shock. Vertical pivots for the arm are of hardened alloy steel. These pivot screws operate in a precision ball bearing to minimize friction in the arm assembly.

The Dynamic Pickup

A dynamic pickup developed by *Fairchild* and illustrated in Figs. 1 and 12 employs a coil which pivots on its own center of gravity. The natural period is determined by the mass of the jewelled tip of the stylus. This is made of diamond. The coil is wound directly

Fig. 11. Mechanical drawing shows internal structure of the Pickering pickup.



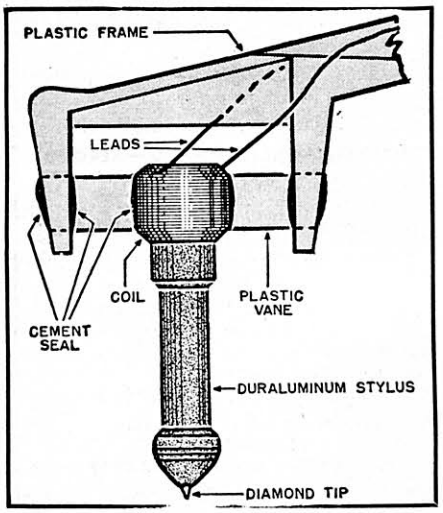


Fig. 12. The Fairchild dynamic pickup. Enlarged view shows assembly of unit.

over a very thin split sleeve of silicon steel mounted around one end of a short duraluminum stylus. The coil, which is wound with number 46 enamel wire, has a d.c. resistance of approximately 35 ohms.

Two thin plastic vanes extend at right angles to the duraluminum stylus, opposite each other and on opposite sides of the coil, then extend up to the towers of a plastic supporting bridge where their ends are anchored. The vanes are lined up with the record grooves and are in the plane of the stylus. Lateral modulation from the record causes these vanes to flex on the center line of the vanes and coil when the jewelled tip of the stylus is placed in the record groove. An oscillatory motion of the coil on its center of gravity results. A small Alnico permanent magnet is included. The positive and negative poles of this magnet are faced with thin cushions of soft synthetic rubber. These cushions are placed in close proximity to each side of the coil. These rubber cushions are necessary to prevent abrasion between the coil and pole pieces and also serve to hold the stylus vertical to the record. The assembly is then mounted on a heavy aluminum plate. The stylus tip is in the form of a tiny diamond pin. This is ground to a ball shape and is highly polished to prevent record wear. Its life, with average discs, is practically unlimited.

An aluminum casting mounts the head on the end of the reproducing arm. A handle is provided to raise or lower the reproducer head and a locking type handle protrudes through a slot in the side of the housing.

The response of this unit is from 30 to 10,000 cycles per second. Features of the lateral dynamic pickup include exceptionally low mechanical impedance of the stylus due to its mounting method, the method of mounting of the pickup cartridge in the arm on a two point suspension in which the entire arm floats at the required height above the disc (the arm being mounted on cone ball bearings which reduce side drag), a permanent dia-

Get YOUR Share of these NEWARK VALUES!

You can use this!



BEACON RECEIVER BC-1206-B

Truly sensational buy for Hams, Experimenters! 5-Tube Set, tunes 195 to 420 Kc. (A-N beam signals. Operates on 28V DC; easily changed to 110V. 4"x4"x6⅝" long. Wt. 3¼ lbs. Complete with tubes, slightly used, A-1 condition, and it's all yours for only..... **$3.95**

An Amazing Buy!

MECK FM CONVERTER



Converts Any Ordinary Radio for Crystal-Clear FM Reception

Now you can have beautiful, clear, static-free FM Reception from your own radio set at a remarkably low price! This wonderful little converter is really terrific! Just plug it into phono jack of regular broadcast receiver, or, connect it like any record player. Incorporates entirely new principle—product of war-time electronic development. More sensitive than most high priced FM receivers. Streamlined plastic cabinet. Cat. No. A-2135, for 110 volt, 60 cycle AC or DC. Complete with tubes and instructions, ready to operate. Shipping Wt., 5 lbs.
Your Cost, Only..... **$14.98**

You can't beat this Price

Army BC-645 V.H.F. Unit

Any Ham, any experimenter can convert this to swell 2-way voice or code set on ham and citizen bands 420 to 500 Mc. 15 tubes alone worth more than price! Now you can own this precision equipment for a tiny fraction of its actual worth. Complete with tubes, less dynamotor **$9.95**



IMMEDIATE DELIVERY!

WEBSTER WIRE RECORDER



FOUNDATION UNIT

Thrilling new Wire Recorder— Reproducer Unit around which you can build a complete instrument. Consists of wire-moving mechanism, recording head that records, erases and plays back, self-starting motor for 110 v., 50-60 cycles, 1-15 minute spool of wire, Osc. coil, instructions.
Inexpensive, simple..... **$52.92**

G-1 HOME RECORDER 78 and 33-1/3 R.P.M.



A smooth and dependable Recorder. Cuts records to 10" diam., plays to 12" diam. Simple cutter feed mechanism. 10" weighted turntable. Crystal pickup. Drawn steel base plate. 15x10"; 2 11/16" above and 2⅝" below base plate. Shpg. wt. 16 lbs. For 115 V 60 cycles.
Model G1-R90..... **$28.37**
Model G1-R70 similar to above but for 78 RPM only..... **24.02**

OAK RECORD CHANGER 2-Post Model



Plays mixed 10" and 12" records. A sturdy, dependable record changer at a price that spells profit for servicemen! Limited Quantity! 110 Volts AC.
Your Cost..... **$17.95**



HANDMIKE T-17

New low price for this perfect 200-ohm carb. handmike; Press-to-talk switch, 5-ft. rubber cd., plug, dust cover, BRAND-NEW **95¢**

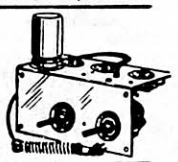
Scoop! Army-Navy Phones H-16U



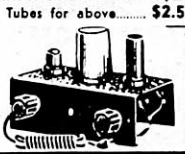
Super quality Phones. 8000 ohms Imped. Rubber covered throughout. Ear cushions, Cord and PL-54 Plug. New — Guaranteed. Adj. headband. Hurry, while they last! Only..... **99¢**

PHONO AMPLIFIER

3-TUBE MODEL



Great Value! Completely wired, ready to operate. Compact, simple to install. For 110 Volts AC-DC. Tone and volume controls, uses 35Z5, 12SK7 and 50L6GT
Cat. No. A10001..... **$2.95**
3 Tubes for above..... **$2.54**



WIRELESS PHONO OSC. KIT Easily assembled. Kit contains complete set of parts, 2 tubes, and full instructions. Wgt. 3 lbs.
Cat. No. A-10020..... **$4.59**
Wired and tested. **$5.69**

Fill your TELEVISION Needs at NEWARK!

ELECTRO-TECH 7" TELEVISION KIT



$77.50 LESS TUBES

17 tubes for above $34.68
Including Tubes. $22.44 Down—$7.93 Monthly
Cabinet for above $22.50
ELECTRO-TECH 10" TELEVISION KIT **$124.50**
19 Tubes for above $59.74
Including Tubes, $36.85 Down—$13.02 Monthly
Cabinet for above $29.50
TRANSVISION 12" TELEVISION KIT with Tubes..... **$239.00**
Only $47.80 Down—$16.89 Monthly
Cabinet for above $39.95

We stock all standard Television Kits, Sets, Accessories, and components. Just tell us what you want — we've got it for you!

TELEVISION COMPONENTS

In stock for Immediate Delivery!

Deflection Yoke, type 201D1	$8.08
Focus Coil, type 202D1	5.34
Yoke Mounting Hood, type 201X1	1.62
Horizontal Output and H. V. Trans.	9.90
R-F Unit Assembly type 7153I	57.48
Width Control, type 201R2	1.30
Ion Trap Magnet, type 203D1	3.82
Deflection Yoke, type 201D2	8.76
Horizontal Blocking, type 208T1	3.53
Width Control, type 201R1	.76

TRANSFORMERS

Horizontal Out, type 204T1	13.52
Vertical Output, type 204T2	5.29
Horizontal Blocking, type 208T1	3.53
Vertical Blocking, type 208T2	3.35
Horizontal Blocking, type 208T3	2.68
Horizontal Output & H. V., type 211T2	13.38

TELEVISION TUBES

7EP4 Sylvania	$22.50	10FP4C Rauland	$52.00
7GP4 RCA	19.40	12JP4 Dumont	69.75
10BP4 RCA	39.60	15AP4 Dumont	129.50

ORDER FROM New York or Chicago
Shipments FOB N.Y. or Chicago
20% Deposit Required with C.O.D. Orders
Send Full Amount of Order—Save C.O.D. Chgs.
Prices Subj. to Change

BUY OVER $75 WORTH OF EQUIPMENT Take ONE YEAR to PAY
20% Down—Pay Monthly

NEW YORK Offices & Warehouse 242 W. 55th St., N.Y. 19

NEWARK ELECTRIC COMPANY, INC.

CHICAGO 323 W. Madison St. Chicago 6, Ill.

New York City Stores: 115-17 W. 45th St. & 212 Fulton St.

A timely break!

MARK TIME SWITCHES WITH A THOUSAND USES



$1.49 NEW—SURPLUS A FRACTION OF THEIR ORIGINAL COST.

CAPABLE OF BREAKING 10 AMPERES AT 110 VOLTS, THIS SWITCH CAN BE SET TO SHUT OFF AT ANY SELECTED TIME WITHIN ITS RANGE.

CALIBRATED IN 15 MIN., STEPS TO 5 HOURS

THIS TYPE OF PANEL MOUNTING SWITCH IS USED BY MANY OF THE LARGEST MANUFACTURERS OF WASHING MACHINES, COOKERS, SUN-LAMPS, AIR CONDITIONERS, MEDICAL AND LABORATORY APPARATUS, VENTILATING FANS, REFRIGERATORS, POWER TOOLS, ELECTRIC FURNACES AND IN A VARIETY OF ELECTRONIC DEVICES.

USE IT TO TURN OFF...

YOUR RADIO, WINDOW OR NEON LIGHTS, SOLDERING IRONS, BATTERY CHARGERS, DAIRY OR POULTRY EQUIPMENT, HEATERS.

CAN BE USED FOR...

VULCANIZING, CLEANING AND DYEING, METAL TREATING, PLATING, TANNING, MOULDING, TEXTILE PROCESSING.

ZACK

RADIO SUPPLY CO.

INCORPORATED

1426 MARKET ST. SAN FRANCISCO, CALIF.

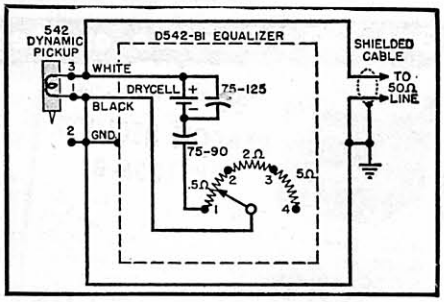


Fig. 13. Equalizer circuit used in conjunction with the Fairchild pickup.

mond-tipped stylus which protrudes about one-quarter inch below the cartridge case making "spotting" easy, a low stylus pressure of approximately 25 grams which results in minimum record wear and combines to make it an almost ideal pickup for dubbing from instantaneous records, and the fact that there is no overhang of the tone arm with consequent inertia which is another cause of difficulty when playing warped records or on uneven turntables.

Equalization of this or any other pickup is afforded through special equalizers usually provided by the manufacturer of the pickup. Such a unit is illustrated in Fig. 13. Four positions are provided: 1. To give approximately orthoacoustic reproduction; 2. Highs attenuated about 6 db. at 10,000 cycles; 3. Flat, and 4. Highs boosted about 4 db. at 10,000 cycles.

Space does not permit a complete resumé of all available moving coil type pickups. It should be pointed out, however, that one of the primary conveniences of capacity and moving coil pickups over magnetic types is that there are no forces inherent in the structures which would tend to displace the stylus and vibrating system. With magnetic designs it is necessary to exert a restoring force sufficient to return the armature to center in opposition to the magnetic attraction to the pole pieces when it swings toward them.

This condition makes it possible to increase the stylus assembly compliance in moving coil types. A low frequency resonance with reasonable tone arm mass may be achieved without difficulty at a sub-audio frequency. In choosing a low frequency for the natural period of a pickup, it is worthwhile to consider the possibility of excitation as a consequence of sub-harmonic effects from various sources such as record hum and motor vibration. Theoretically, then, perfect magnetic and moving coil pickup designs would function so as to provide constant output from constant velocity recordings and equalization is therefore necessary only to compensate for constant amplitude recording characteristics in the lower register.

As mentioned in previous chapters, the theoretical response curve for X-cut Rochelle salt crystal pickups is flat in terms of constant amplitude recording and should normally require equalization to raise the response in

ORDER AND SAVE! THE WALMAR WAY!

TUBES

705A..$2.95..708A..$2.90..715A	$4.05
5U4, 6J5, 6K7, 6SL7, 6SN7, 6SJ7, 12A6, 6L7	.59
12SA7, 12SK7, 12SQ7, 12SH7, 12AH7, 6SA7	.61
2X2, 6A6, 2050, 6B7, 2A3, 6AC7, 2050	.84
6SG7, 6SC7, 6SS7, 12H6, 6H6	.60

CONDENSERS—OIL FILLED—C.D.—AEROVOX

.1 mfd, 3X.1, 2X.1, 1, @ 600v	$0.26
C.D. type TJH 1 mfd 2000v	1.35
C.D. type TJH 4 mfd 2000v	3.95
C.D. type TJH 10 mfd 1000v	1.90
C.D. type TJH .5 mfd 2000v	1.05
.01, .02, .001, .03 mica @ 1000v	.28
.005 mfd 3000v. Mica	.38

RESISTORS

100 Insulated AB, 1 and 2 W	$2.25
1.5 meg. 1.5K.V. Precision Meter Multiplier-Weston	1.85
500 ohm 50 Watts I.R.C.	.85
3000 ohm 50 Watts Ohmite Model K	1.35

RELAYS

G.E. 115V. AC 10v. DC Coil	$1.75
Dunco 115v. AC DPST	2.25
28v. DC DPDT, Allied	.69

TRANSFORMERS

WECO, STANCOR, ETC. 115v. AC 50-60 cycles

D-161912 Sec. No. 1, 2.6v. @ 10 amp., Sec. No. 2, 6.4v. @ 5.5 amp. C tap, Sec. No. 3, 6.4v. @ 1 amp. C tap	$3.95
D-161913 2500v. RMS @ 0.012 amp.	2.95
D-161916 Sec. No. 1, 680v. @ 225 ma. DC, Sec. No. 2, 1540v. @ 20 MA DC.	4.15
D-161937 115v. AC 50-60 C. Sec. 6.4 @ 8.5 amp.	2.25
R.F. Coil forms G.E.	$0.73
Z-O R.F. Plate Chokes	.11
Antenna loops w/trimmer	.59
OSC. Coils 465 KC	.28

All Prices F.O.B. Baltimore

WALMAR DISTRIBUTING CO.

3803 BEEHLER AVE.

Baltimore 15, Md.

BARGAINS

6 V Guardian RELAY SPST Norm open *2 for*	$0.79
Single Mike to Grd TRANS Ferranti	.75
Double Mike to Grd TRANS W.E.	.95
Sine Wave Potentiometer 32,000 Ohms Sickles	3.25
11.7 to 250 mmf variable Hammarlund ball bearing rotor	1.19
10.3 to 171 mmf variable Hammarlund ball bearing rotor	.97
10.3 to 191 mmf variable Hammarlund ball bearing rotor	.97
250 ass'd coded RESISTORS; ½, 1, 2, W; pop sizes No. MX11	4.95
50 ass'd MICAS pop sizes mkd or coded No. MX12	1.95
21 TRANSMITTING MICAS .00003 to .02, 600 and 1200 WVDC, Solar XCB and Micamold (3 ea. size) No. MX13	2.25
TRANSFORMER, Hi voltage, 1200v 12-ma, 110v 50-60 c in No. T31	2.25
CHOKE, fltr; 15 hy 500 ohms, 10ma UTC 73037 shldd No. T34 *2 for*	.79
CHOKE, fltr; 4 hy 300 ohms 90 ma, Westinghouse shldd No. T35 *2 for*	.79

Hundreds of other Bargains. Also Test Equipment Kits Designed and Developed by ROBERT G. HERZOG—Write for free data, circuits and lists.

UNIVERSAL GENERAL CORP., Dept. N.

365 Canal St., New York 13 Walker 5-9642

LEARN RADIO!

IN ONLY 10 MONTHS

PREPARE FOR A GOOD JOB!

COMMERCIAL OPERATOR (CODE)

BROADCAST ENGINEER

RADIO SERVICEMAN

Television Servicing—15 Months

(Approved for Veterans)

SEND FOR FREE LITERATURE

BALTIMORE TECHNICAL INSTITUTE

1425 EUTAW PLACE, BALT. 17, MD.

Are You Getting Our Flyers???

If not, PRINT your name and address on a penny postcard. It will mean dollars in the bank for you!! Ask for our latest catalog and flyer.

RADIO EQUIPMENT CO.

377 E. Main St. Dept. RN Lexington, Kentucky

"YOUR FRIENDLY PARTS HOUSE"

the constant velocity section of the recorded spectrum. Most commercial designs are characterized by a resonant peak in the vibrating system at approximately 3000 to 4000 c.p.s. Advantage is often taken of this condition by broadening the peak and allowing this natural period to compensate for losses in the constant velocity range. Furthermore, since many reproducing systems are deficient in bass response, a rising characteristic in this region may be desirable where cost is a major factor.

Possibly the greatest advantage of crystal cartridges, then, is a very high output voltage obtainable and the consequent reduction in amplifier gain requirements. The customary equivalent circuit for piezoelectric pickups is a generator with no internal impedance in series with a condenser. The shunt capacitance of a cable connection to the input of an amplifier may then be considered in combination with a crystal capacitance as forming a non-frequency discriminating voltage divider.

In conclusion, therefore, we find after examining the many pickups available that our choice will largely depend upon the application for which we intend to use the pickup as well as the price we wish to pay. Like a watch, precision comes at a high price but as far as results are concerned, there is no substitute for quality.

(To be continued)

PHILIPPINE HAM CLUB

TEDDY KALAW, Jr., KA1TK, was elected president of the Philippine Amateur Radio Association at a recent meeting of that organization. Serving with Mr. Kalaw for the coming year are Earl Hornbostel, vice-president, and Elpidio G. De Castro, secretary-treasurer.

Members of PARA may be contacted through Mr. De Castro, KA1RTI, by writing him in care of Radio Training Institute, 345 Palma Street, Quiapo, Manila, Philippines. —30—

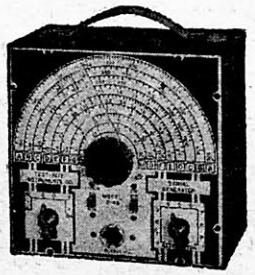
A group of Geiger-counter tubes makes a real handful as can be readily seen in the photo. The Geiger-counter tubes shown are, from left to right, for detecting soft x-rays and Beta rays; for use in quartz crystal analysis units; and for special x-ray research work. The tubes are manufactured by the Philips Laboratories, Inc., subsidiary of the North American Philips Co., Inc.



METROPOLITAN is the largest specialized testing instrument house in the country. We carry approximately 5,000 testing instruments in stock of all nationally advertised brands. The items listed below are only a few selected models offered at specially attractive prices in order to meet the present day demand for good merchandise, at fair prices. All units factory guaranteed for one year and available for immediate delivery from stock.

The New Model B-45 Battery Operated

SIGNAL GENERATOR



for servicing AM, FM and Television Receivers. R.F. frequencies from 150 Kilocycles to 50 Megacycles (150 Kc. to 12.5 Mc. on Fundamentals and from 11 Mc. to 50 Mc. on Harmonics). Complete with shielded test lead, self-contained batteries and instructions.

Net..... **$27.75**

The Model 689-IF

WESTON OHMMETER



A convenient, pocket size ohmmeter for checking circuits by the resistance and continuity method. The energy for the resistance reading is supplied by a self-contained 1.5 volt No. 2 standard large flashlight cell. Built to meet U. S. Army Requirements for Accuracy and Durability!

This Ohmmeter also has a double range 0-10 and 0-1000 ohms for the accurate measurement of low resistance values. Model 689-IF comes complete with operating instruction, test leads and LEATHER CARRYING CASE.



List price $25.50
Our Price..... **$14.85**



The New Model 111 AC-DC QUALITY MULTITESTER

A new pocket-size volt-ohm-milliammeter with features never before available in an instrument of this size and price.

D.C. Voltmeter: 0-5-50-250-500-2500 volts, A.C. Voltmeter: 0-10-100-500-1000 volts. Output Voltmeter; 0-10-100-500-1000 volts. D.C. Milliammeter: 0-1-10-100 milliamperes. D.C. Amperes: 0-1-10 amperes. Ohmmeter: 0-500-100,000 ohms; 0-1 megohm. Decibel Meter: —8 to +55 db. The scale is calibrated for line of 500 ohms impedance. For other impedances correction charts are supplied. Model 111P, in portable case (not illustrated) including testing leads and complete instructions..... **$19.85**

Model 111A, open-face, as shown, complete with instructions..... **$16.85**



The New Universal

COMBINATION TEST SPEAKER

A new combination test speaker plus resistor substitutor; plus condenser substitutor; plus resistor tester; plus condenser tester; plus output meter.

A MUST FOR EVERY RADIO SERVICE MAN AND ENGINEER

No need to carry the speaker to your shop in servicing any radio from the small midget to the most elaborate console. Any output tube or tubes can be matched simply by rotating input switch to listed tube and rotate field switch for proper impedance and proceed with testing. External voice coil connection permits testing of set-speaker to determine if output transformer is open or shorted. Field impedance: 500, 1000, 1500 and 2500 ohms at 175 Ma.

This unit comes housed in a rugged, battleship gray, crackle-finished steel cabinet, with operating instructions, size 7"x11"x5", operates on 110 V., AC, 60 cyc. Complete.....Net price **$27.50**

Model 570 PREMIER Band Spread Dial

SIGNAL GENERATOR



AIR TRIMMERS ON ALL BANDS.

TRIPLE COPPER-PLATED SHIELDING.

EFFECTIVE LINE FILTER-pure 400 cycle modulation (less than 5% distortion).

Range 75KC-50MC on fundamental, and 50-150MC on 3rd harmonic, useful for aligning FM and Television Receivers.

Accuracy better than 1%.

A. C.—115 volts, 50-60 cycles.

Overall size—12"x12½"x5½". Shpg. wt. 21 lbs.

Complete with co-axial cable and operating instructions. **$54.75 NET**

ORDERS FILLED SAME DAY RECEIVED

TERMS: 20% Deposit, Balance C.O.D. Or Full Payment with Order

SEND FOR FREE CATALOG

We repair all types of testing instruments. Write for information

Metropolitan ELECTRONIC & INSTRUMENT CO.

Dept. R-11, 42 WARREN STREET, NEW YORK 7, N. Y., U. S. A.