1952

RADIO & TELEVISION DATA
for
RADIOTRICIANS* & TELETRICIANS*

(*Registered U. S. Patent Office)

Prepared as a Service
Especially for Members of the

NATIONAL RADIO INSTITUTE ALUMNI ASSOCIATION
Washington 9, D. C.

Compiled by John H. Battison,
Director of Education, National Radio Institute

Reprinted from
TELE-TECH and RADIO & TELEVISION RETAILING

CALDWELL-CLEMENTS, INC.
480 Lexington Ave.
New York 17, N. Y.

TV Receiver Manufacturers Ready

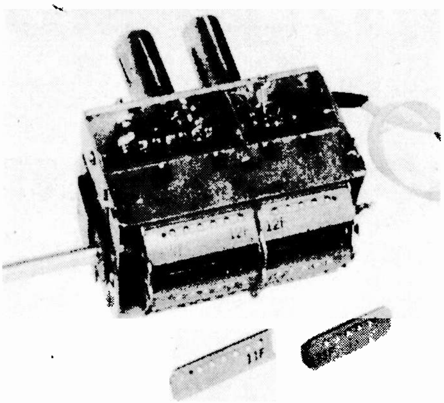
Set makers show FCC and industry engineers various means for adapting

WHILE at Washington the engineers of the FCC and the broadcast stations work to set up a UHF TV allocation (see large chart accompanying this issue of TELE-TECH), the manufacturers of TV sets also have been busy designing conversion devices which will permit present VHF standard TV sets to receive stations in the UHF band.

And although a year or two may elapse before UHF-TV becomes a matter of actual general operation in the United States, the manufacturers well recognize that TV sets going on the market this Fall will be expected to serve their owners for a number of years and so must be simply convertible to receive UHF signals when these do come on the air in 1952, '53 or '54!

Bridgeport Tests

Progress in UHF conversion of standard TV receivers of many makes was high-lighted several weeks ago when the RTMA invited the FCC members and engineers to a demonstration of UHF adapters, held at Bridgeport, Conn., where NBC has an experimental UHF transmitting station in regular operation.



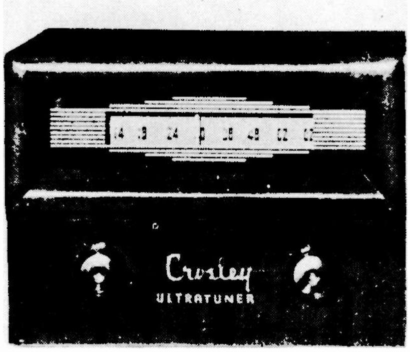
CAPEHART-FARNSWORTH—Using a regular Capehart CX-33 receiver chassis, four miles from the Bridgeport transmitter ultra-high-frequency conversion was accomplished by inserting UHF channel strips in Standard Coil tuner already a part of instrument. Complete Capehart line uses same chassis.

The TV receiver makers had set up their conversion devices in the bedrooms of Bridgeport hotels, about 4 miles from the transmitter, and the Washington officials trooped from room to room, watching the clear, bright UHF pictures received on 529-535 megacycles at 4 miles distance, and comparing these with the same program—snowy and diathermy-ridden—received on VHF channel 4 from New York, 56 miles away.

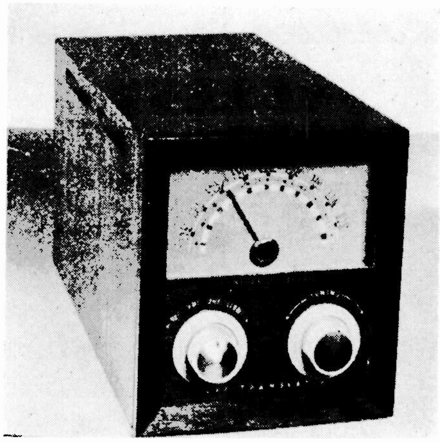
In this respect, the Bridgeport demonstrations proved almost too convincingly that UHF gives superior results without reception difficulties. For as the manufacturers' experimental engineers vied with each other to bring in perfect UHF reception in the lofty hotel rooms, the non-technical observers did not always stop to think what corresponding quality of UHF reception would be possible in the homes of an average city or town with hills and building obstructions.

Downlead Problems

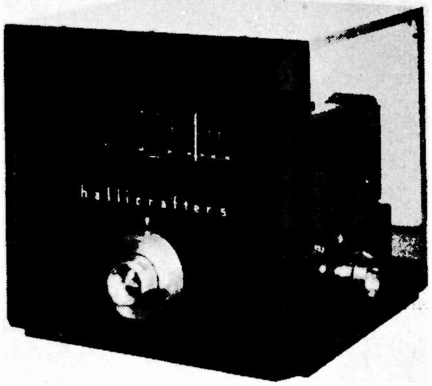
Difficulties of carrying UHF signals many feet from antenna to chassis were also apparent. One maker had installed a roof-top antenna 25 ft. away but experienced such losses in the down-lead, that a built-in antenna in his converter box gave practically the same effective signal! The tiny UHF antennas of pencil length, however, showed the simplicity of the UHF pick-up problem for direct-view locations. Some UHF antennas were simply stuck up on the wall with adhesive.



CROSLEY—"Ultra tuner" measures 7 x 7 x $9\frac{1}{2}$ in.; attached by screwdriver to receiver. Works with any continuous-tuning TV receiver. One model Ultratuner with self-contained UHF antenna. Installation requires no work on receiver. Covers 122 to 132 megacycle frequency range. Retail price, about $40.



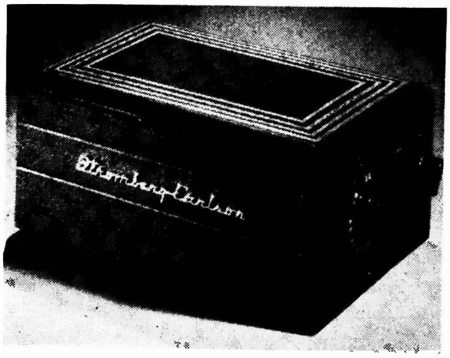
GENERAL ELECTRIC — This Translator (Model UHF-101) has been tested for 18 months in the Bridgeport area and is now in limited production. Below the megacycle numerals there is a logging scale for added convenience in tuning. A travelling dial light spot-illuminates each numeral.



HALLICRAFTERS' new ultra-high-frequency converter operates over a 450- to 900-megacycle range. The output frequency feeds into either Channel 3 or 4 of any present-day television receiver. The Hallicrafters Company also has UHF coil strips available for its turret-type "Dynamic Tuners."

with UHF Conversion Devices

present standard VHF sets to receive programs from future UHF stations.



STROMBERG-CARLSON'S converter, styled in green leatherette and measuring only 8 x 4 x 6 in., uses a 6F4 as a local oscillator, a 6BQ7 as a cascode r-f preamplifier, and a 1N72 germanium crystal mixer. Unit has a 12MC bandwidth and balanced output feeds VHF-TV channels 5 or 6.

To the lay Commissioners, the novel converter container shown by Stromberg-Carlson in the form of a handsome tooled-leather cigar box, attracted special attention, and pointed a possible trend of decorative camouflaging which purchasers may demand, if UHF converters are to be kept on top of their present TV receivers in their living rooms.

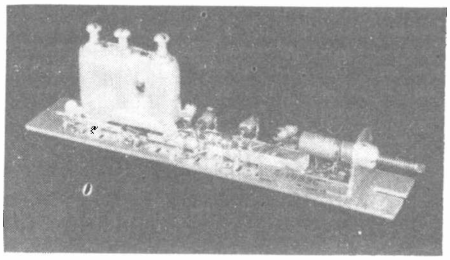
Pictured herewith are a number of UHF converters or translators which have been developed by TV manufacturers for their own receivers or for general use with all or most receivers. Included also are several designs which were not demonstrated at the RTMA-FCC Bridgeport session.

Other Exhibits

In the case of certain converting devices exhibited at Bridgeport, photographs were not released but information as follows was made public at the individual session:

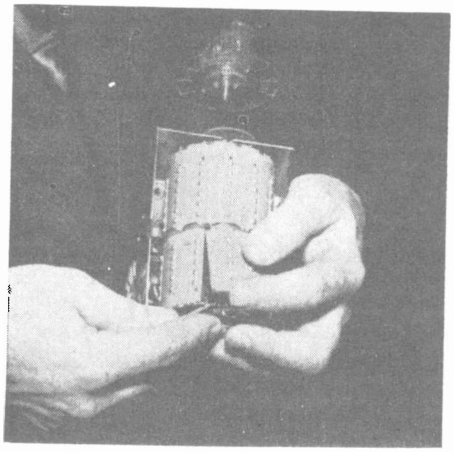
PHILCO—While this company has been experimenting with several types of UHF conversions, it demonstrated at Bridgeport only an external converter with continuous tuning which may be attached to any Philco TV set. This covers the full range of proposed UHF channels and is easily attached. Philco also has its tiny "match-box" single-channel converters which may be made available later, for use under appropriate conditions.

RCA VICTOR—Designed to bring in all UHF channels and suitable for attachment to any television receiver, the RCA converter was shown to give pictures that compare favorably in every respect with VHF reception. On the face of the attractively designed converter are two knobs and an easily read dial. Installation of the converter is sufficiently simple to be performed from an instruction sheet by the average set owner. Retail price, about $50.



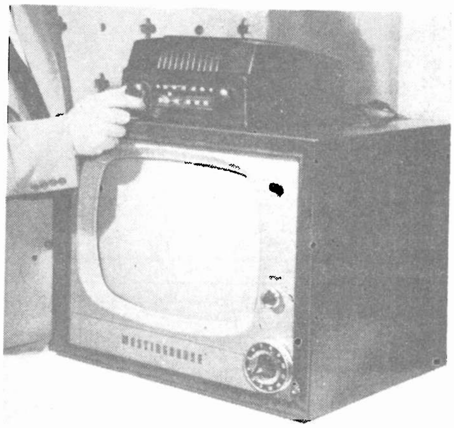
ZENITH—During the FCC Bridgeport demonstrations, Zenith engineers showed how a UHF strip (like that pictured) could be slipped into the Zenith tuner in a very few minutes, enabling the standard receiver to operate on UHF without any change in the set itself

MALLORY—Means for converting standard television receivers were demonstrated at the Stratfield Hotel, Bridgeport, and inspected by the FCC party, but photographs and technical details requested by TELE-TECH were not available at press-time.



STANDARD COIL — Simple transfer of strips in tuner, readies any set so equipped, for reception of uhf signals within a few minutes. The two-section strips in effect turn TV set into a double conversion circuit. CK 710 diode is used as converter. Fingers shown belong to Edwin Thias, engineering VP.

TARZIAN—Full-band UT-1 tuning unit for ultra-high-frequency telecasts is adaptable to any set now in use; does not interfere with VHF channels. Self-contained power supply. No electrical changes are necessary in present television sets. Unit may be placed on top of the set or installed inside.



WESTINGHOUSE—With this new UHF converter, the set is capable of receiving all uhf channels, in addition to standard telecasts in the very-high-frequency range. The converter, housed in a mahogany finished wood cabinet, can be easily connected to all Westinghouse television receivers now in use.

Receiving Antennas

Three-year field tests near Washington, D. C. for UHF operation on basis of electrical

By E. O. JOHNSON and J. D. CALLAGHAN

Radio Corporation of America,
Camden, N. J.

REQUIREMENTS for the reception of television signals on the UHF band (470 - 890 MC) are much the same in many respects as on the existing VHF band (54 - 216 MC). For the more difficult fringe areas, or locations where reflections are severe, special types of antennas will be needed, just as they are in VHF.

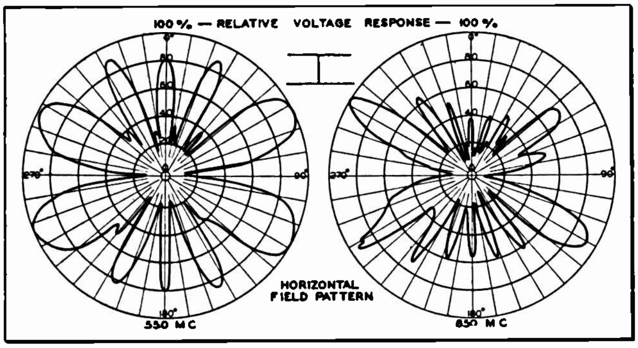
Of the wide variety of special UHF antennas designed and tested during field tests in Washington and Stratford, near Bridgeport, Conn., from 1948 to the present, several types have proved so outstanding in their simplicity, economy, and performance, that it is felt they will find additional widespread use where maximum performance and reliability are primary considerations.

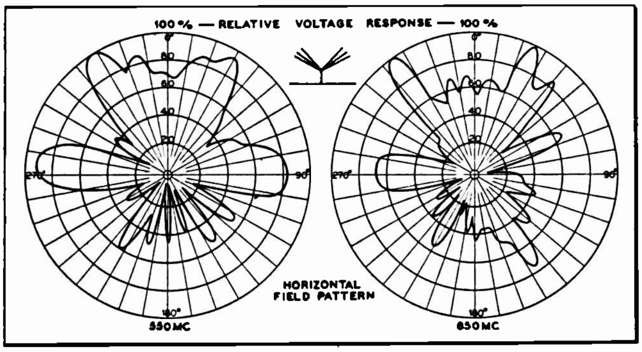
Each of these special types possesses properties peculiar to its individual design, and these types should provide a choice that will meet the requirements of even the most difficult locations.

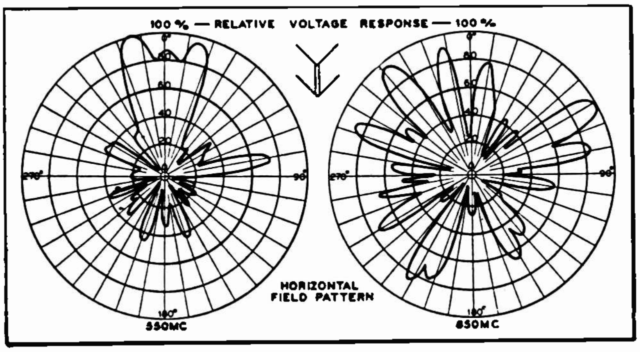
While the factors of performance, size, ease of installation, appearance, strength, cost, and availability of materials must all be considered in UHF antenna design, this discussion will be limited to performance, as determined by the electrical characteristics.

Antenna characteristics are classified here according to gain, directivity, and bandwidth, as follows:

Gain—Antennas may be roughly classed as "low gain" or "high gain," depending on their design for use in strong signal areas or weak signal areas. It should be noted that in all







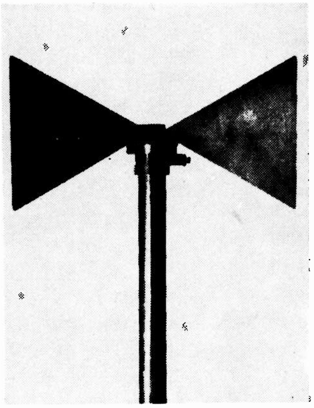


Fig. 4: Fan dipole

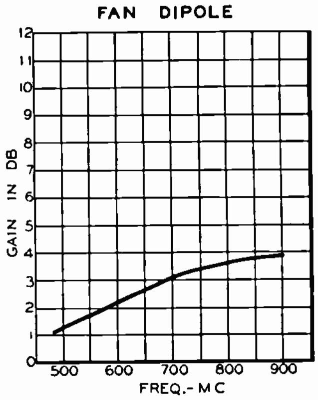
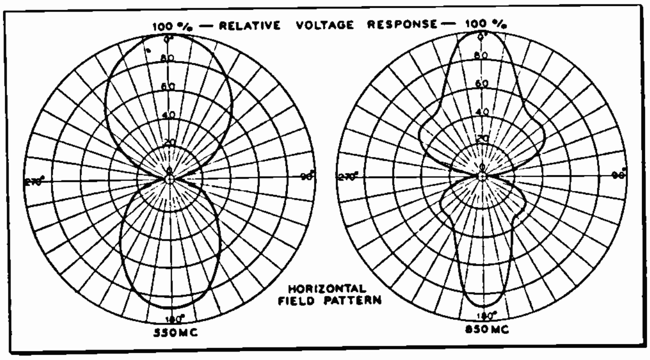


Fig. 5: Fan dipole gain

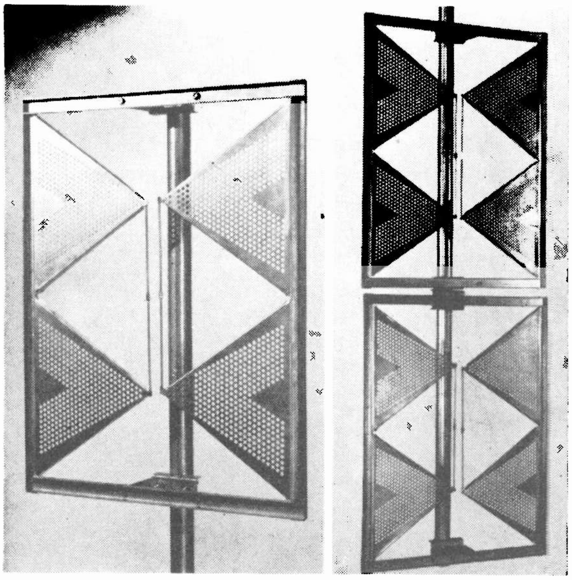
Figs. 1-3: (Left) Diagrams showing (above) horizontal field patterns for Channel 2 dipole and reflector, (center) VHF fan-type dipole and reflector, (bottom) VHF double V antenna

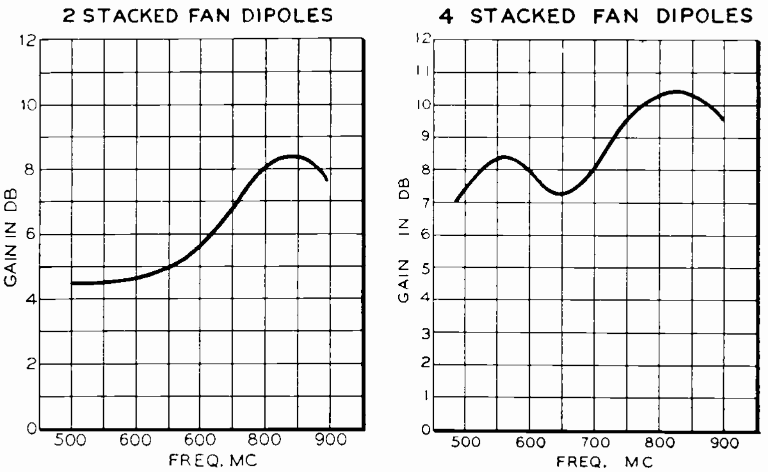
Fig. 6: Horizontal field pattern showing directivity of fan dipole



for UHF Television

and Bridgeport, Conn. reveal antenna types best suited performance, mechanical simplicity, and cost economy





Figs. 7-10: (Left) Physical appearance of two-stacked (left) and four stacked fan dipoles. (Above) Gain vs frequency for the two types

the gain curves shown, the 0 db reference line is the gain of a thin half-wave dipole adjusted to resonance at each individual frequency. Thus, any given point on the gain curve references the antenna under discussion back to a half-wave-length dipole resonated for that particular frequency. The antennas shown have been designed to work into a balanced 300-ohm line, the gain curves were obtained by using a 300-ohm load at the antenna, and the reference dipole was also matched into 300 ohms.

Directivity—This can vary from the low-gain omni-directional antenna, which receives from all directions, to the highly specialized uni-directional antenna, which has a very narrow angle of reception from one direction only, thus discriminating against unwanted signals. Directivity can be further broken down into horizontal and vertical planes. Horizontal directivity can often be used to great advantage in reducing reflections and multi-path cancellation of signal from objects in directions other than that of the transmitting station. Vertical directivity is often very useful in removing the effects of signal cancellation due to reflection from the earth or other objects either above or below the path between the receiving antenna and the transmitter. This also makes the placement of the antenna less critical. Flutter of signal caused by airplanes is often substantially reduced by an antenna with high vertical directivity. Since high directivity and high gain usually go hand in hand, the so-called "fringe area" type of antenna is very useful in metropolitan areas to eliminate reflections or multi-path conditions.

Bandwidth—Antennas may also be classified as to their bandwidth, i.e., their ability to receive signals efficiently over a wide range of frequencies. Since the UHF spectrum covers 70 television channels, the design of these antennas sometimes seems unconventional when compared to the usual type of antenna designed for single-channel operation.

VHF Antennas at UHF

Most VHF antennas are not very satisfactory at UHF, except in medium and high signal strength areas which are free from reflection problems. Their general UHF characteristics are:

Gain—Low, varying from approximately 10 db below a resonant dipole to 3 db above that of a resonant dipole when they are oriented for maximum response.

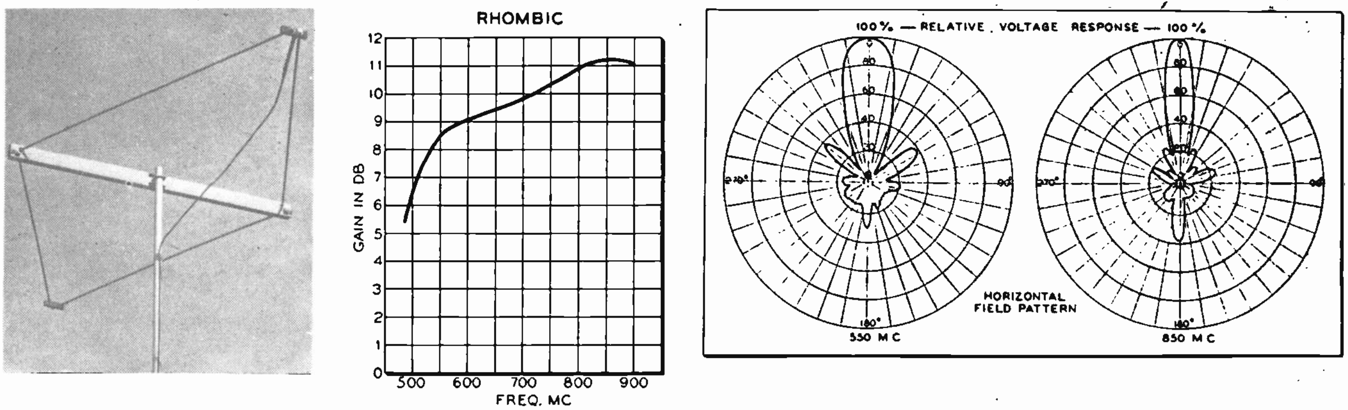
Directivity—Poor in both the horizontal and vertical planes. This is due to the many lobes present and the fact that the major lobe does not usually fall on the axis of the antenna. Figs. 1, 2, and 3 show the horizontal polar patterns of three widely used types of VHF antennas at 550 and 850 MC.

These, as well as other polar patterns in this article, are shown in terms of relative voltage with the maximum lobe being equal to 100%. Because the television receiver is essentially a voltage-sensitive device, signals picked up by any of the minor lobes will appear on the receiver in the same relation as shown on the chart. Polar patterns are sometimes shown in terms of power, which will make the same antenna appear to be more directive. Thus, a minor lobe showing only 10% response in a power plot, will actually be 31.6% in voltage.

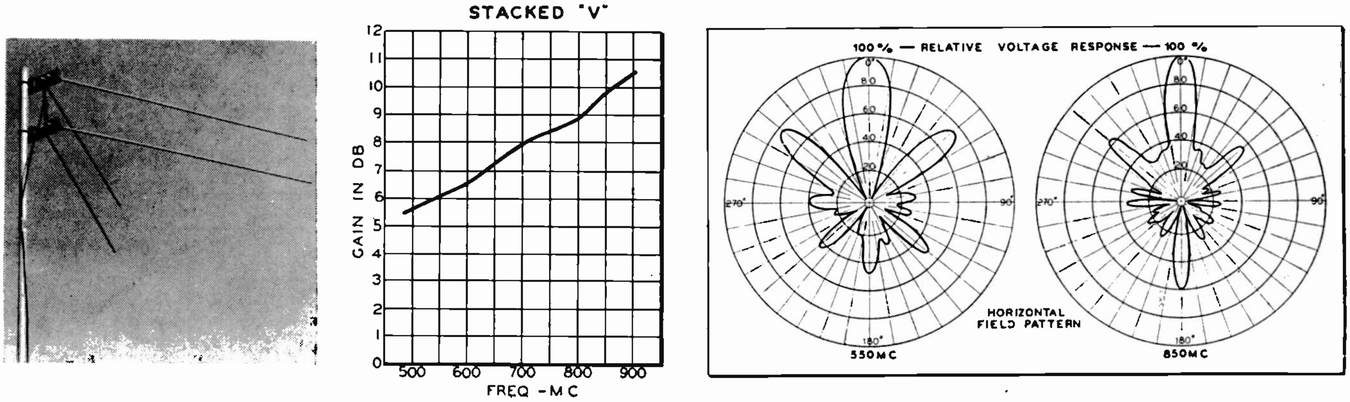
Bandwidth—This is generally adequate, with the gain falling off somewhat toward the high end of the band. A major disadvantage is that the main lobes shift direction with frequency, requiring separate orientation for stations operating on widely separated channels.

Fan Dipole

This dipole, shown in Fig. 4, is one of the simplest of all UHF antennas. The antenna is constructed of two triangles of metal, supported



Figs. 11-13: Physical appearance, gain vs frequency curve, and horizontal field pattern directivity for rhombic antenna



Figs. 14-16: Physical appearance, gain vs frequency curve, and horizontal field pattern directivity for stacked "V" antenna

by a suitable insulator. Both triangles lie in the same plane, and the transmission line is attached to each apex. Its characteristics are as follows:

Gain—The gain is shown in Fig. 5. It will be noted that this antenna shows some gain over a half-wave dipole because of its unique construction.

Directivity—Typical directivity patterns are shown in Fig. 6. While a slight front-to-back ratio seems unusual for a dipole antenna, the reduction in response in one direction is caused by the metal mast and mounting support.

Bandwidth—As can be seen from Fig. 5, the bandwidth of the triangular shaped dipoles is excellent.

Stacked Fan Dipoles

The simple fan dipole can be stacked vertically, as shown in Figs. 7 and 8. When properly phased, the gain of the two-stack fan dipole is that shown in Fig. 9, and that of the four-stack fan dipole is that shown in Fig. 10.

This stacking will result in an increase of vetrical directivity, although the horizontal directivity will remain as shown in Fig. 6.

It will be noted that the bandwidth, while still good, is not quite as uniform as that of the single fan dipole. This is mainly due to some frequency selectivity in the individual transmission lines used for phasing the dipoles.

Rhombic Antenna

Rhombic antennas have been built and used very successfully during all the UHF field tests. One of these is illustrated in Fig. 11. These rhombics have been adjusted for unidirectional operation and are usually terminated at the far end with a suitable resistor. The general characteristics are as follows:

Gain—High, as shown in Fig. 12, making this antenna very well suited for fringe area operation.

Directivity—This is also very good, as shown in Fig. 13. It will be noted that the major forward lobe is quite narrow in the horizontal direction, decreasing in width with increasing frequency. While some minor side and back lobes are present, these should give no trouble except in very severe cases of reflections or multipath reception. Although the vertical directivity pattern is not shown, the major lobe in the vertical direction is approximately three times as broad as that shown for the horizontal.

Bandwidth—This is a broad-band type of antenna, showing a rising gain characteristic toward the high-frequency end of the band, which is very desirable.

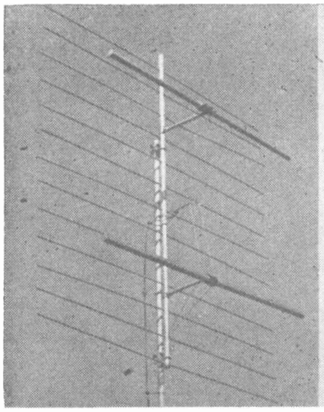
Stacked Rhombics

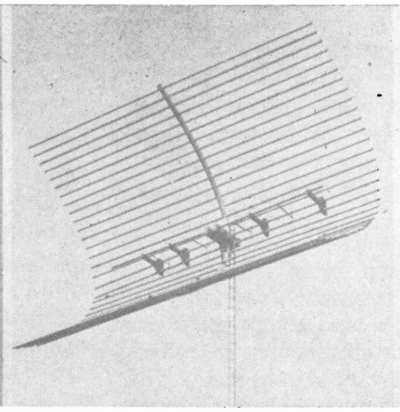
Two or more of these rhombics can be stacked vertically, one above the other. When two of these antennas are stacked 12 inches apart, the result is an increase in gain of about 2 db across the entire band.

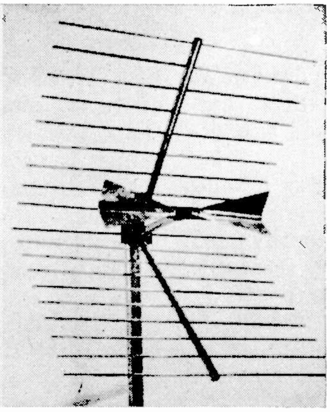
This stacking also increases the vertical directivity, although the horizontal directivity will remain approximately as shown in Fig. 13.

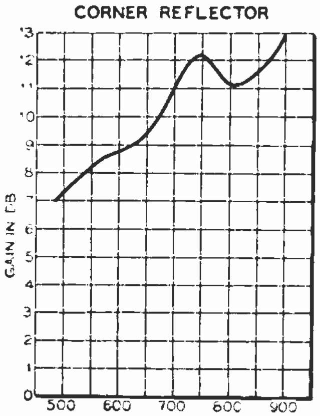
Stacked "V"

Two "V" type antennas stacked one above the other are illustrated in Fig. 14. This combination uses the same rods as a standard dipole made for Channel 2, and thus contains about the same amount of metal as a simple VHF dipole and reflector. It is a very efficient antenna, considering its simplicity of

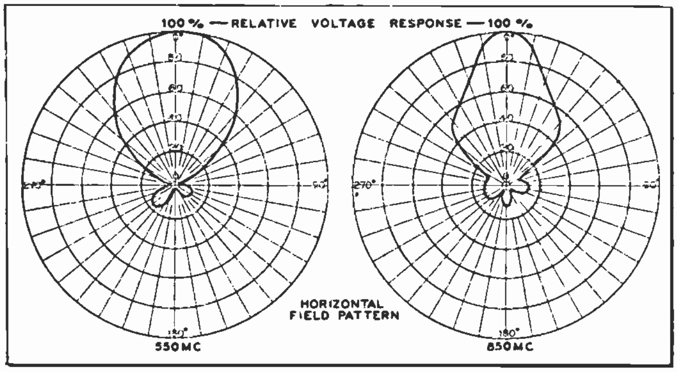








Figs. 17-20: Sheet reflector-type antennas (l. to r.) Flat sheet, parabolic reflector, and corner reflector with gain vs. frequency curve



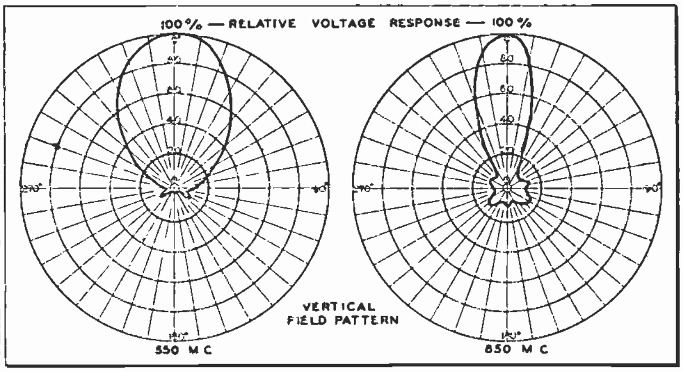


Fig. 21: (Left) Horizontal directivity field pattern for corner reflector. Fig. 22: Vertical directivity field pattern for corner reflector

construction, and is relatively easy to mount on existing masts. It shows the following characteristics:

Gain—This is a relatively high-gain antenna (as shown in Fig. 15) for use in medium and weak signal areas. It also shows an increasing gain characteristic with frequency, which is highly desirable to overcome both propagation and transmission line losses which increase with frequency.

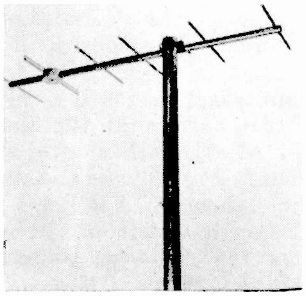
Directivity—The directivity pattern, as shown in Fig. 16, indicates one narrow major lobe, plus multiple secondary lobes. This should be adequate in most areas that are reasonably free of reflections.

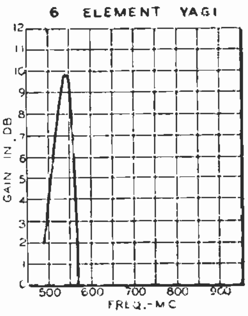
Bandwidth—The bandwidth of this antenna is excellent, covering more than the required frequency spectrum.

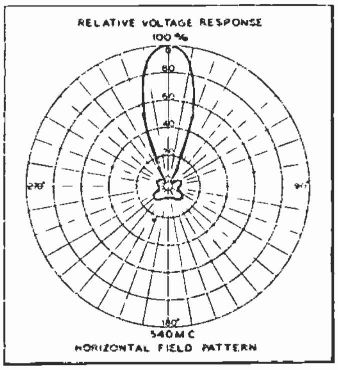
Sheet Reflector Types

Sheet reflector-type antennas, wherein one or more dipoles are arranged in front of a large metallic sheet, have been in use for some time in such applications as radar and micro-wave transmission.

Although they can take many forms, three experimental types are shown here, Fig. 17 showing dipoles arranged ahead of a flat sheet; Fig.

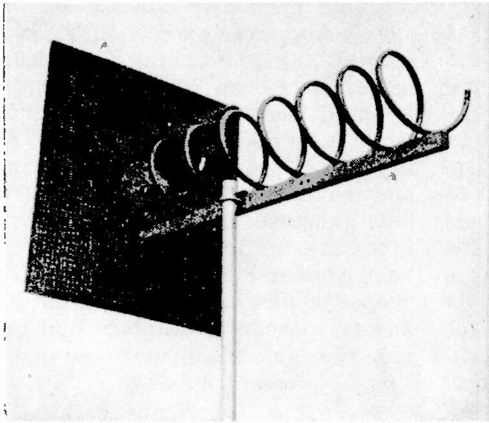


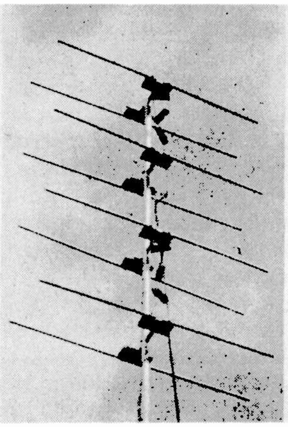




Figs. 23-25: (Left) UHF Yagi, (center) gain vs frequency for 6 element Yagi, (right) horizontal field pattern for latter

Fig. 26: (Left) Helical antenna. Fig. 27 (Center) Stacked dipoles and reflectors Fig. 28: (Right) Slot type antennas may be used extensively on UHF-TV





18 showing five co-linear dipoles at the focus of a parabolic sheet; and Fig. 19 showing a modified fan dipole of a corner reflector.

While the ideal reflector is a solid sheet of metal, a multiple number of rods or a wire mesh is generally used to reduce wind resistance, ice loading, and weight. This is perfectly satisfactory from an electrical standpoint, provided that the openings in the metal are only a small fraction of a wave length.

Being one of the most compact and highly efficient of the sheet reflector types, the corner reflector has been selected for discussion here. This particular antenna uses a 90° included angle in the corner and a modified type of fan dipole as the antenna element. It will be noted in Fig. 19 that the fan dipole is also folded at 90° to conform to the shape of the reflector. Following are its characteristics:

Gain—This antenna has the ultimate in gain for its compact size, as shown by Fig. 20. It should be one of the best performers in fringe areas.

Directivity—This antenna is also an outstanding performer in directivity, being truly uni-directional. The directivity in the horizontal plane is shown in Fig. 21, and the directivity in the vertical plane in Fig. 22. The almost complete absence of unwanted lobes should reduce reflection and multi-path troubles to an absolute minimum.

Bandwidth—Although the corner reflector antenna is normally considered to be a relatively narrow-bandwidth antenna, the combination of a proper-size reflector and the unique design of the dipole element has resulted in a compact, high-gain antenna which covers the entire UHF spectrum.

Yagi Antennas

The Yagi is a familiar type of high-gain, narrow-bandwidth array which can be equally as useful at UHF as at other frequencies. It produces more gain for its size and weight than any other types of antenna. The mechanical construction of a yagi to operate at these frequencies is very critical, and close dimensional tolerances must be held if its high gain is to be realized. The one illustrated here (Fig. 23) is a six-element, wide-spaced type. At UHF, advantage can be taken of the increased gain afforded by wide spacing without a structure which is prohibitive in size. The antenna shown here has an over-all length of only 28 inches.

Gain—The gain curve is shown in Fig. 24. While this should be adequate for most weak signal installations, still higher gains may be obtained by stacking two or more of these antennas in the conventional manner.

Directivity — The horizontal directivity pattern of this antenna is shown at its resonant frequency in Fig. 25. This is also a very excellent pattern for the elimination of reflections and unwanted signals. The vertical directivity pattern shows only a slightly greater lobe width than the horizontal pattern.

Bandwidth—This is a very narrow bandwidth antenna, showing its peak gain only on the channel for which it is made. It may be noted, however, that a total of seven UHF channels fall within the range of this antenna if a sacrifice in gain of 3 db at either end of the pass band can be tolerated.

Almost any type of antenna used at other frequencies can be designed for operation on the UHF television band. Simple types, such ordinary dipoles, dipoles and reflectors, and combinations of these can be used effectively, although they will not show the broad bandwidth characteristics of the previously described special types. One such array of dipoles and reflectors is shown in Fig. 27.

Also worthy of mentioning are several experimental types which are too cumbersome to use at lower frequencies, but adapt themselves very readily in this portion of the spectrum. They are the helical-type antenna, shown in Fig. 26, and the slot-type antenna, shown in Fig. 28.

Transmission lines are an important part of the receiving antenna system, and many types of lines have been evaluated during the field tests. The best antenna performance can be obtained only by the proper choice and installation of the transmission line. Because of the much greater loss in the flat ribbon types of transmission line under adverse weather conditions, those used with the most success in experimental UHF installation have been Types 2, 3, and 4, in the list below. The 300-ohm tubular line, while better than the flat line under conditions of soot, grime, and moisture, still shows an appreciable increase in loss. The coaxial types are not affected, but naturally have greater initial attenuation. The proper choice of transmission line and its proper installation will provide the same trouble-free service as that obtained on present VHF channels.

	Type	Loss — DB/100 Feet 100 MC Dry	 Wet	 500 MC Dry	 Wet	 1,000 MC Dry	 Wet
1	Standard 300-Ohm Flat Line	1.2	7.3	3.2	20.0	5.0	30.0
2	Tubular 300-Ohm Line	1.1	2.5	3.0	6.8	4.6	10.0
3	RG 59/U Coax	3.7	—	9.6	—	14.5	—
4	RG 11/U Coax	1.9	—	5.2	—	7.8	—

The antennas discussed above are all of the balanced 300-ohm type. Where it is found desirable to use an unbalanced 75-ohm coaxial transmission line, or where the receiver is designed for 75-ohm unbalanced input, an impedance transformer and balancing network are necessary to couple these two unlike items together. This balancing network is referred to as a balun, and the impedance transformer can be conveniently incorporated in the same structure.

A lightning arrestor is often necessary on UHF as well as on VHF. Lightning arrestors designed for VHF use have proven unsatisfactory at UHF, due to their electrical mismatch and signal loss. The balun incorporates positive lightning protection in its design, without the losses of standard lightning arrestors, provided its case is adequately grounded.

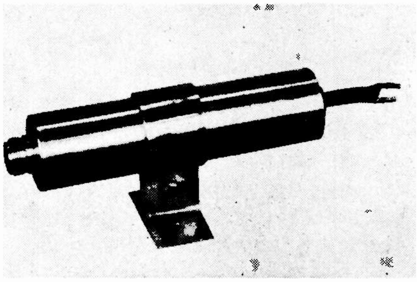


Fig. 29: Balun for matching balanced 300-ohm line to unbalanced 75-ohm coaxial

Typical installation procedure when using 300-ohm line is to install the balun (shown in Fig. 29) on the outside of the building near the entrance point of the transmission line, and to attach a lightning ground to its case. Coaxial line is then run to the 75-ohm input of the receiver.

If coaxial line is used throughout, the balun is installed at the antenna and the shield of the coaxial cable is properly grounded at the entrance to the building.

Naturally, it will be to everyone's advantage to make UHF installations as simple and economical as possible. The approach in adding UHF to present VHF may be to utilize one of the following procedures:

a. Investigate the possibility of using the existing VHF antenna and transmission line—compromising antenna orientation where necessary.

(*Continued on page* 41)

JTAC COLOR TELEVISION SYSTEM COMPARISON TABLE

Tabulation of color TV characteristics and standards, prepared by Joint Technical Advisory Committee for FCC, presents details of competing systems

System	Horiz. Resolution Dots Per Line (5) (6)	Vert. Resolution Number Lines (6)	Product of H and V Resolutions	Frame Flicker		Interline or Interdot Flicker and Crawl (7)		Smoothness of Motion		Color Break-Up (8)	Receiver Changes Needed for Compatibility (12)		
				M	C	M	C	M	C		M (9)	C (10)	Comparison (11)
A1—6-MC Monochrome. 30 Frames. 60 Fields. Present Commercial System.	507	525	266 x 10³	Equal	—	Equal	—	Equal	—	—	—	—	Equal
B1—12-MC Simultaneous Color. 30 Color Pictures. 60 Fields. (1) G = 4MC; R = 1.8 MC; B = 1.4 MC. Like system demonstrated by RCA in 1947. "Mixed Highs" employed.	G 507 B 507 R 507 M 507 (25)	G 525 B 525 R 525 M 525	G 266 B 266 R 266 M 266	Equal	Equal	Equal	Equal	Equal	Equal	No	None	N. F.	Equal (13)
C1—12-MC Field Sequential Color. 24 Color Pictures. 144 Fields. Like system demonstrated by CBS in 1947.	C 528 M 528	C 525 M 525	C 277 M 277	Inf.	Inf.	Equal	Equal	Sup.	Inf.	Yes	N. F.	N. F.	N. A.
C2—6-MC Field Sequential Color. 24 Color Pictures. 144 Fields. Like system demonstrated by CBS in 1949-50	C 275 M 275	C 405 M 405	C 111 M 111	Inf.	Inf.	Equal	Equal	Sup.	Inf.	Yes	a–d	a–c and f–h	Inf. (14)
C2A—6-MC Field Sequential Color. Dot and Line Interlaced. 12 Color Pictures. 144 Fields. Like system demonstrated by CBS to FCC on April 26, 1950.	C 550 M 550(15)(26)	C 405 M 405	C 222 M 222 (15)	Inf.	Inf. (16)	Equal (17)	Equal (17)	Sup.	(18)	(19)	a–d (20)	a–c and f–h	Inf.
C3—6-MC Field Sequential Color. 20 Color Pictures. 240 Fields. (2) Dot and Line Interlaced.	C 420 M 420	C 315 M 315	C 132 M 132	Sup.	Sup.	Equal	Equal	Sup.	Equal	Yes	a–e	a–c and f–h	Inf.
D1—6-MC Line Sequential Color. 30 Color Pictures. 60 Fields. Simple Interlace. Alternate odd lines R, G, B, then alternate even lines R, G, B.	G 507 B 507 R 507 M 507	G 175 B 175 R 175 M 175-525	G 89 B 89 R 89 M 89-266	Equal	Equal	Inf.	Inf.	Equal	Equal	No	None	i	Inf.
D2—6-MC Line Sequential Color. 30 Color Pictures. 60 Fields. Non-interlaced. (3) First Field G, R, G, R, then Second Field G, B, G, B.	C 504 M 504	G 264 R 132 B 132 M 264	G 133 R 67 B 67 M 133	Equal	Inf.	Equal	Inf.	Equal	Inf.	No	None	i	Inf.
D3—6-MC Line Sequential Color. 10 Color Pictures. 60 Fields. Simple Interlace Plus Color Line Commutation. Under development by Color Television, Inc. in 1949-50.	C 507 M 507	C 525 M 525	C 266 M 266	Equal	Equal	Inf.	Inf.	Inf.	Inf.	No	None	i	Inf.
D3A—6-MC Line Sequential Color Line Interlaced with Color Commutation. 10 Color Pictures. 60 Fields. Like system demonstrated by CTI to FCC on May 17, 1950.	C 507 M 507	C 525 M 525	C 266 M 266	Equal	Equal	Inf.	Inf.	Inf.	Inf.	No	None	i	Inf.
E1—6-MC Dot Sequential Color. 15 Color Pictures. 60 Fields. (4) Dot and Line Interlaced. (3) Line Sequence G, R, G, B.	G 254 R 254 B 254 M 254-507 (26)	G 525 R 262 B 262 M 262-525	G 133 R 67 B 67 M 67-266	Equal	Equal	Equal	Inf.	Equal	Equal	No	None	i	Inf.
E2—6-MC Dot Sequential Color. Dot and Line Interlaced. 15 Color Pictures. 60 Fields. "Mixed Highs" like system demonstrated by RCA in 1949-50.	G 507 B 507 R 507 M 507(25)(26)	G 525 B 525 R 525 M 525	G 266 B 266 R 266 M 266	Equal	Equal	Equal (17)	Equal (17)	Equal	Equal	No	None	(21)	(22)
F1—6-MC Frequency-Interlace Color. 30 Color Pictures. 60 Fields. Standard Line Interlace "Mixed Highs" under development by G.E. Co.	G 507 B 507 R 507 M 507(25)(26)	G 525 B 525 R 525 M 525	G 266 B 266 R 266 M 266	Equal	Equal	Equal	Equal	Equal	Equal	No	None	(23)	(24)

LEGEND:
- M—MONOCHROME (BLACK & WHITE)
- C—COLOR
- G—GREEN
- B—BLUE
- R—RED
- INF.—INFERIOR
- SUP.—SUPERIOR
- N. F.—NOT FEASIBLE
- N. A.—NOT APPLICABLE

(1) Committee agrees that optimum performance requires less bandwidth for blue and red channel than for green channel. The numbers shown were suggested by RCA.

(2) Interlaced in both directions. Vertically in the usual fashion, horizontally by pulsing the video signal with an 8-mc dot carrier.

(3) Suitable correction is applied for the excess of green.

(4) The video signal is pulsed with an 8-mc dot carrier and the colors are changed at both line and dotting frequencies.

(5) A picture dot is a half cycle of the top frequency of the nominal video band. For example, in present commercial transmission, with a nominal video band of 4 megacycles a picture dot lasts ⅛ microsecond. A scanning line lasts 63.4 microseconds. Hence, the number of picture dots per line is 507.

(6) Blanking times are ignored throughout, because figures are not available for some of the systems.

(7) It is assumed that brightness and viewing distance are such that there is no frame flicker and the scanning lines are just not resolved. It was agreed that for the systems considered, susceptibility to flicker and crawl are not appreciably different. In some different systems, susceptibility to small-area flicker may be different from that to interline crawl. For system D1, there will be an increased tendency for interline flicker because of the assignment of a specific line to a specific color.

(8) In systems C1, C2 and C3, longer persistence phosphors, as used in the all-electronic receiver, have almost eliminated color break-up.

(9) To allow present receivers to receive color transmissions in monochrome.

(Continued on page 48)

Recent Developments

A review of the semi-conductor junction types feature small

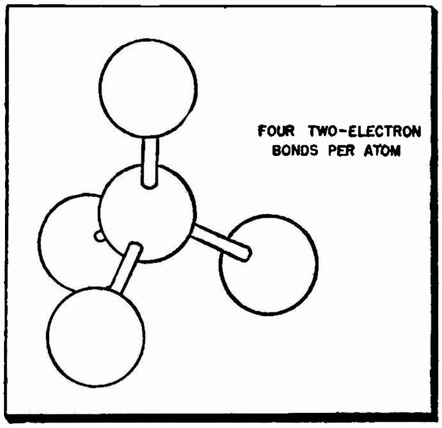


Fig. 1: In a perfect insulator electrons are tied up in interatomic bonds and cannot participate in conduction

By Dr. JOHN S. SABY
Electronics Laboratory,
General Electric Co.
Syracuse, N. Y.

Power Transistors Soon?

Important new developments in germanium diode manufacturing techniques have resulted in a design suitable for ac power rectification purposes. These new diodes are reported to have ratings of approximately 350 ma at 130 volts r.m.s., and as such, as capable of providing dc power requirements of the average television receiver, (General Electric type G-10).

Research in this field, accentuated by shortages of selenium, is speedily going forward with a view towards the ultimate development of types capable of handling 2-10 amperes of current. If this can be achieved, new forward steps might well lead to the development of power transistors. In turn, the availability of power transistor types would truly make germanium semi-conductors a direct substitute for vacuum tubes. With the added features of simplicity, long-life, ruggedness, and greater power conversion efficiency, their extensive application in future designs of both receivers and transmitters becomes a certainty.—*Editors.*

THE art of making semiconductor devices is slowly becoming a science. Fundamental studies of the origin, nature, and behaviour of p-n junctions in semiconducting materials have charted paths for this transition. This article may be regarded as a progress report along one of the paths of this development from art to science.

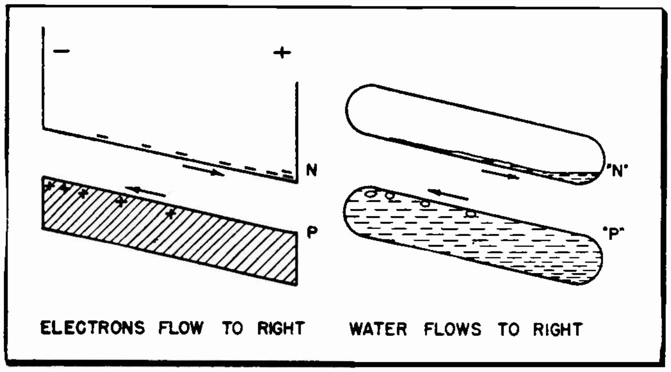
One of the first fruits of the scientific approach to semiconductor work has been the development of the transistor. Let us compare the new p-n junction transistors to the earlier types, and make some guesses as to the extent of future applications. In order to make educated guesses, a physical picture of some of the electronic processes which take place within semiconductors and which determine their properties, will be briefly outlined.

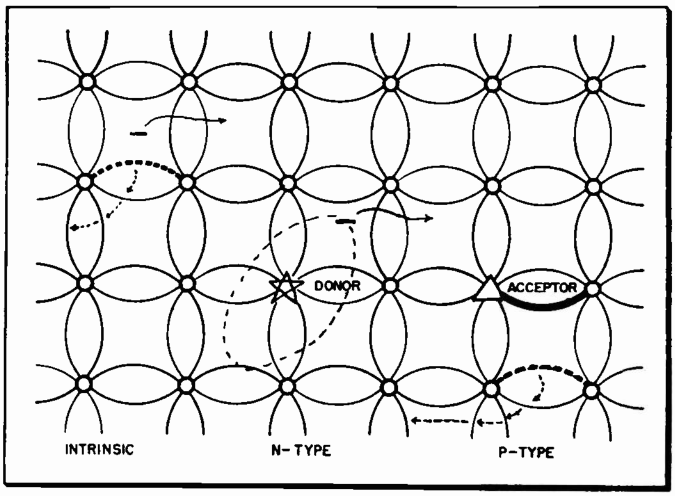
This picture will not be complete or fully accurate as to detail, but will give an essentially correct concept of why these devices work.

A semiconductor has certain electronic properties intermediate between those of metals and insulators. In defining these it is to be noted that metal contains a number of so-called "free" electrons, whereas a perfect insulator has none. All of the electrons in a perfect insulator are tied up in interatomic bonds and cannot participate in conduction (Fig. 1). Conduction is possible, however, at high temperatures when a few electrons are thermally excited. At these temperatures the elec-

Fig. 2: Two conduction processes

Fig. 3: (right) Conduction centers





in Transistors and Related Devices

characteristics and their applications in transistors. New p-n-p
size, high gain, low noise, high efficiency and improved stability

trons are torn loose from their bonds and can move about and conduct electricity. The heated insulator has now become what is termed an intrinsic semiconductor. There is no sharp distinction between insulators and intrinsic semiconductors. If the electronic bonds are easily broken, then a noticeable amount of conduction will take place even at room temperature, and the material is called a semiconductor.

Two Conductivity Processes

In reality, two conductivity processes take place simultaneously in an intrinsic semiconductor as shown in Fig. 2. If an electric field is impressed on the semiconductor, electrons will flow from left-to-right in the conduction band, just as the liquid will flow along the bottom of the nearly empty tube when tilted. This type of conduction is called n-type conduction.

Neighboring electrons in the filled band, however, also can jump into the vacancy left by a flowing electron thus leaving new vacancies elsewhere. As the electrons fill up vacancies they drift from left-to-right, the holes move right-to-left, just as the bubbles in the nearly filled tube move right to left when liquid is really flowing left to right. Since the holes move in the opposite direction to that of the electron in an electric field, they can be regarded for some purposes as + charges. This is called p-type conduction.

Another source of holes and electrons are impurity atoms. Atoms with 5 valence electrons, i.e., with one extra valence electron (these atoms are called donors) may enter the lattice substitutionally and contribute to n-type conduction as shown in Fig. 3. Correspondingly, lattice defects or impurity atoms (called acceptors) with only 3 valence electrons instead of Germanium's four can trap electrons, leaving unsatisfied bonds, or "holes", nearby which can contribute to p-type conduction. All these conduction processes are important in germanium. When conduction is principally by conduction-band electrons, a semiconductor is called n-type; when it is principally by holes, it is called p-type. When n- and p-type regions occur in the same crystal, the boundary between the p-type and n-type materials is called a p-n junction.

A p-n junction itself comprises a rectifier which operates roughly as sketched in Fig. 4, where for simplicity the only charges shown are those contributing to conduction: If the p-region is made positive, the holes move right-to-left, electrons move left-to-right. They move toward each other and recombine. The forward voltage need only be enough to keep this current going. If p-region is made negative and the n-region positive, then holes and electrons move away from each other. The region between has its movable charges removed and thereby becomes an insulator.

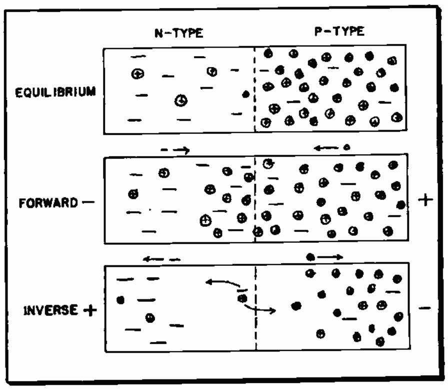


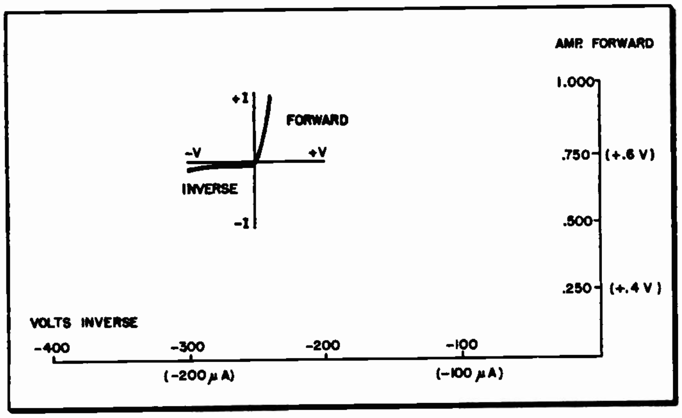
Fig. 4: Rectification by a P-N Junction

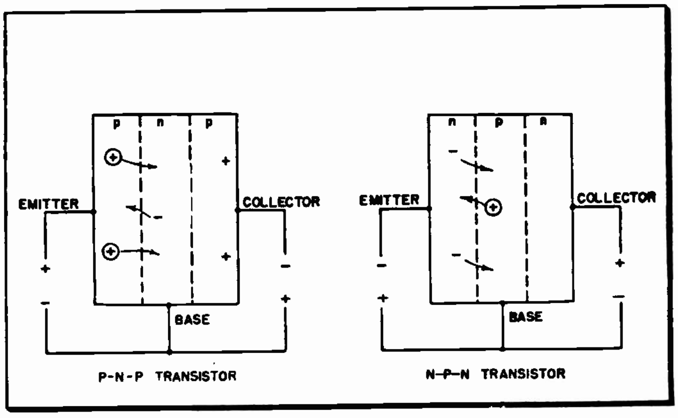
The back current should be composed mainly of hole-electron pairs created thermally in this region and should be expected to increase rapidly with temperature.

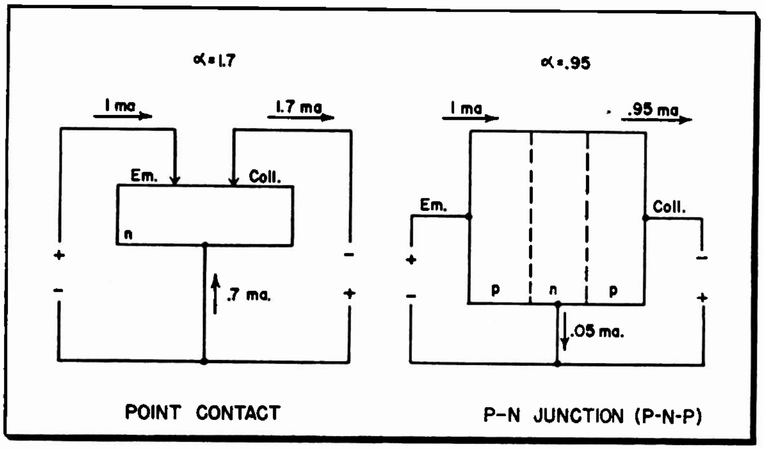
Diffusing Impurities

At GE a process for diffusing donor and acceptor impurities into germanium so that n-p junctions can be produced at will has been developed. This process is described by Hall and Dunlap of the General Electric Research Laboratory ("Physical Review", Nov. 1, 1950). Characteristics for a typical rectifier made in this way appear in Fig. 5. Similar units have been made which will withstand inverse potentials greater than 700 volts, drawing less than two milliamperes leakage current. These units can be broken down repeatedly by high inverse voltage without permanent damage. The peak current densities in the forward direction are of the order of

Fig. 5: (left) E-I characteristics in diffused P-N junction germanium rectifier. Fig. 6: (right) P-N junction transistors







POINT CONTACT

P-N JUNCTION (P-N-P)

Fig. 7: Comparison of transistors

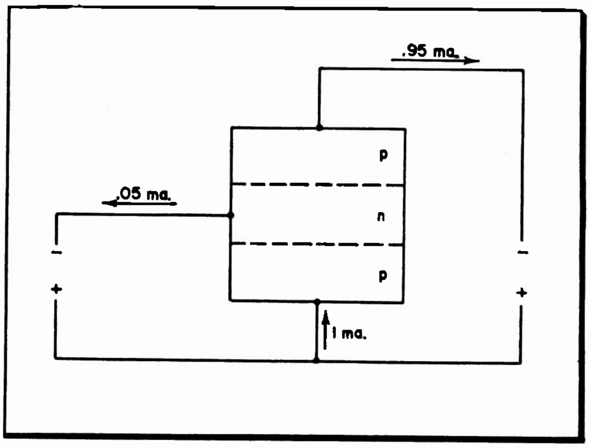


Fig. 8: Circuit current gain $\alpha/(1-\alpha)$

hundreds of amperes per square cm. and the efficiency of these diffused rectifiers is better than 99%. This compares to efficiencies in the 80's for tubes, in the 70's for selenium rectifiers.

Barrier Layer

The p-n junction transistor is a logical consequence of the single p-n junction rectifier. Returning to Fig. 4, note that a p-n junction rectifies by the virtue of a barrier layer which is non-conducting only because there are no carriers in it. If the barrier is thought of as a hindrance to current flow, this hindrance is more analogous to a desert than to a mountain. When carriers are introduced into the barrier region, conduction does take place. One way to introduce carriers is to heat up the device. This however, is not an easily controllable method. Another way is to shine light upon the junction. This can photo-electrically excite hole-electron pairs. A family of photo diodes or photo transistors using this mechanism has come into being. The control method most applicable to electronic circuits, however, is injection of carriers by conduction through a p-n junction.

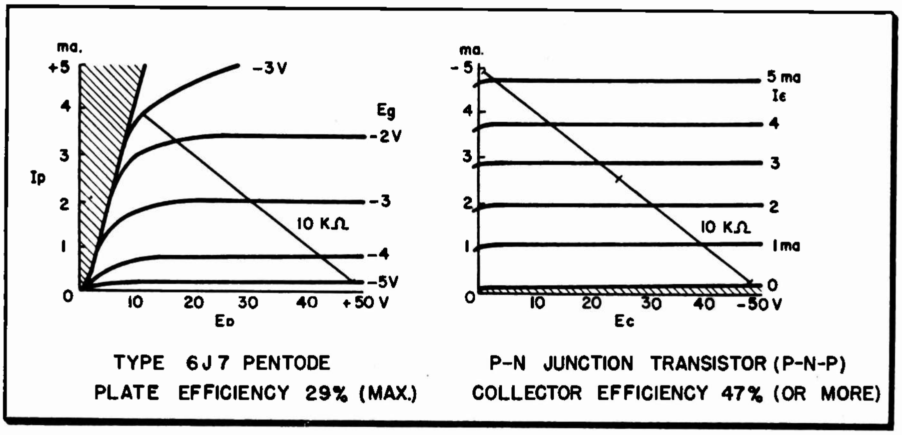
By a process developed in the Electronics Laboratory of General Electric, based on the diffusion process mentioned above, two p-n junctions are arranged back to back in a single crystal of G_e as shown in Fig. 6. This particular transistor consists of a sandwich of two p-type regions separated by an n-type region. Separate electrical contacts are made to each region. Two diodes are thus formed, back to back. The right-hand diode will be operated in the inverse direction. The left one will be operated in the forward direction, in which hole and electrons flow toward each other. Some of the current flowing across the left p-n junction is in the form of electron flow to the left, some consists of holes moving to the right. In particular, if there is a greater density of holes in the p-type region than of conduction electrons in the n-type region, most of the current crossing the barrier will be in the form of holes. The p-n junction is not a barrier for holes moving from left to right, and most of these injected holes can reach the collector and appear as current in the collector circuit. To put it very simply, the leakage current through the right hand junction has been increased by hole injection through the left hand junction. The ratio of changes in collector current to the changes in emitter current is called alpha. If the collector current were injected 100% as holes, and if none of these recombined with electrons before reaching the collector, alpha would be unity. In practice, however, alpha is never quite unity.

The n-p-n junction transistors operate in a corresponding way shown on the other sketch in Fig. 6. In this case, the emitter injects electrons into the p-type base material, and these electrons are collected by the positively biased collector.

Operating Principles

At this point, a comparison in operating principles with the older point contact transistors is in order. Fig. 7 shows them side by side. In the point contact transistor, as in the new p-n-p types, the emitter injects holes into n-type germanium, and these holes appear in the barrier region of an inverse biased rectifier. In the case of the point contact transistor, however, there is a physical multiplying effect, resulting in more current being collected than was originally emitted, 1.7 times as much for a typical unit, (i.e., alpha = 1.7). Herein lies the fundamental distinction between the two types. The new p-n-p or n-p-n junction transistors have alpha less than unity. When alpha is greater than unity as in the point contact transistors, the base current may reverse

Fig. 9: Curves of Class A efficiency.—tubes vs transistors



TYPE 6J7 PENTODE
PLATE EFFICIENCY 29% (MAX.)

P-N JUNCTION TRANSISTOR (P-N-P)
COLLECTOR EFFICIENCY 47% (OR MORE)

direction, and circuit impedances can become negative, leading to short circuit instability. But the new units with alpha less than unity are completely free of this short circuit instability.

It would seem, at first thought, that high alpha would be an advantage, but high current gain in a circuit can be achieved with alpha less than unity. For example, the base current is small in the new transistors so that we may connect the transistor as shown in Fig. 8 with the signal applied to the base electrode. In this case the output signal current change is about 19 times the input original current change. The value .95 is not to be taken as an upper limit. Higher alpha p-n-p transistors have been made. Circuit current gain increases rapidly as alpha approaches unity and, for example, if alpha equals .99 the circuit current gain is 99.

The above remarks are hypothetical and predict certain general characteristics. Next, the actual physical realization of units with these highly desirable characteristics will be described.

Acceptor impurities are diffused into corresponding regions on opposite sides of a thin wafer of n-type germanium, forming a p-n-p sandwich as described above. A number of n-p-n transistors have also been made by diffusing donor impurities into p-type germanium, but all the results given here apply to the p-n-p units with which there is more experience.

At this point, it would be well to outline a summary of the salient features of these new transistors for comparison with the point contact transistors and with vacuum tubes.

1. SIZE: The new transistors can be completely enclosed in a plastic bead less than ¼ inch in diameter. They are much smaller than the tiniest subminiature vacuum tube. How much smaller they can be made depends largely on assembly techniques. There seems to be no fundamental limit in size.

2. POWER ECONOMY: Like the older transistors, the new p-n junction transistors require no filament power at all. They respond instantly when switched on and require no standby power to keep them warmed up.

The efficiency may be compared with the vacuum tubes by reference to Fig. 9, where the shadded areas may be regarded as inaccessible to voltage swings. To obtain the maximum theoretically possible Class A efficiency of 50% in a tube, it would be necessary to be able to operate the tube down to zero plate voltage, and to be able to swing the grid to complete cutoff. For the type 6J7 pentode, with the plate supply voltage and load resistance shown, the maximum efficiency is 29%. The new transistors can operate down below one volt on the collector without serious distortion, and can approach close to the theoretical maximum Class A efficiency of 50%.

3. HIGH GAIN: Power gains on the order of 40 db stage have been measured using matched impedances. Direct coupling of stages is possible with good gain. Maximum utilization of these devices requires a reexamination of circuit theory from a new point of view. The gain depends, in any case, upon the equivalent circuit parameters, and further development of desirable parameters assures even higher gains as development proceeds.

4. STABILITY: Since alpha is always less than unity, p-n junction transistors are entirely free of the short circuit instability which plagued the point contact transistor.

5. LOW NOISE: Quantitative studies of large numbers of units remain to be made, but preliminary data indicate these units are several orders of magnitude quieter than point contact transistors.

6. WIDE POWER RANGE: These units are efficiently usable in the microwatt power dissipation range. Units provided with more area for heat dissipation have been operated continuously above 1 watt. The upper limit of power dissipation on these units has not yet been established.

7. RUGGEDNESS: When properly encased in a plastic bead, these units are mechanically very sturdy.

8. FREQUENCY RESPONSE: P-N Junction transistors have full gain at audio frequencies. They have a usable amount of gain at radio frequencies, depending upon the circuitry used. The upper limit of high frequency response is a complicated function of collector capacitance, transit time, and other effects. Since each upward extension of the frequency range can open new fields of application, high frequency studies will naturally be an important phase of future developments.

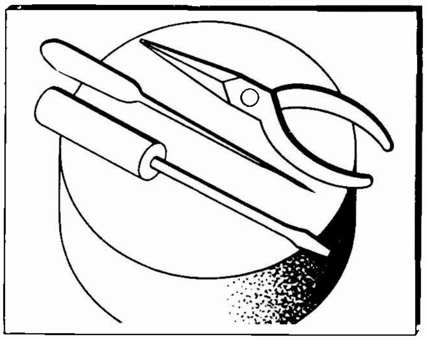
9. SIMPLICITY: An outstanding feature of the new transistor is the simplicity of construction. There is no heater to burn out, no cathode to deteriorate, no wire grids to vibrate microphonically. There is nothing to wear out. The heart of the transistor is simply a piece of Germanium with three wires firmly attached.

To what extent it will be possible to replace vacuum tubes by transistors remains to be seen. For one thing, it is not a mere matter of replacement in existing vacuum tube circuits. Circuits must be redesigned to take advantage of the characteristics of p-n junction transistors. But wherever space, power dissipation, and ruggedness are important, transistors will be called upon to serve. Their development is still in its infancy, but the results already obtained are very encouraging. As the making of semiconductor devices becomes less and less of an art, and more and more of a science, continuous improvements may confidently be expected.

SHOP HINTS

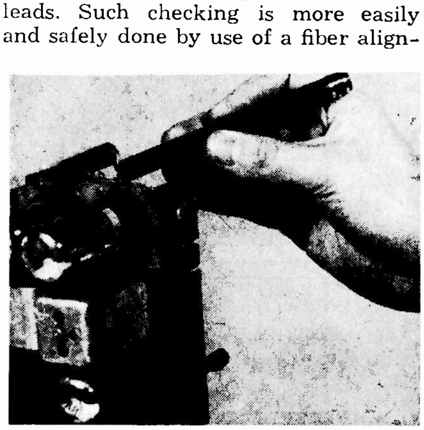
Small Tool Holder

Take a magnet from an old PM speaker (or a couple of them), put it on the front of a test instrument or steel drawer, and park your small tools thereon: those miniature phono needle screwdrivers, scribers, etc. They'll be out in plain sight, easy to grab, and not buried down in the bottom of a tool drawer or box.—*F. C. Hoffman, Radio Doctor, 309 Harrison St., Kewaunee, Wisconsin.*



Checking Condensers

Tubular condensers which intermittently open or short are often located by pulling or twisting the condenser leads. Such checking is more easily and safely done by use of a fiber aligning tool having a slot in one end. The slotted end may be slipped over the bare condenser wire and twisted without danger of shock.—*H. Leeper, 1346 Barrett Ct., N.W., Canton 3, Ohio.*



Heater-Induced Hum

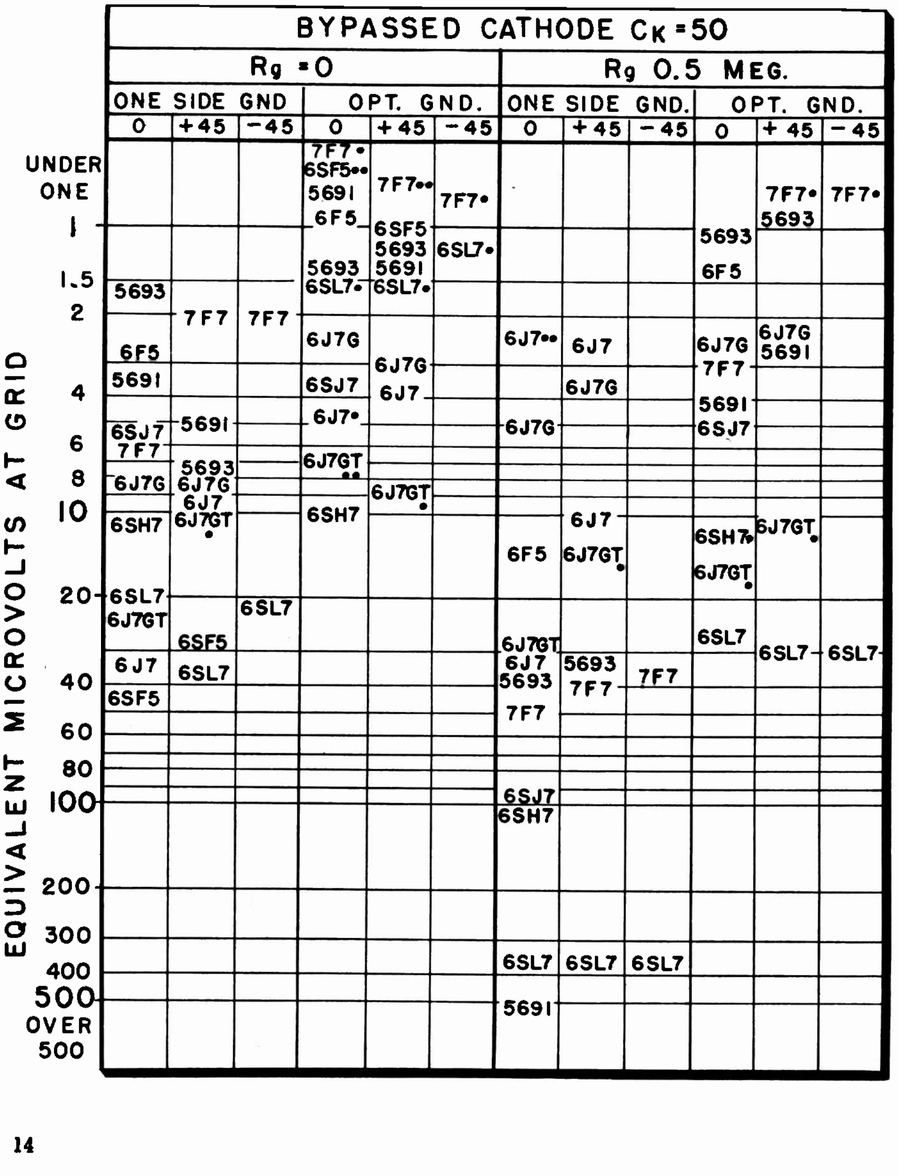
60-cycle hum in eleven different tube types are catalogued for bypassed and unbypassed cathode conditions

By suitable choices of tubes and circuitry, heater induced 60-cycle hum in ac operated low-level amplifiers can be reduced to less than 1 microvolt. Less fortunate tube and circuit combinations may give heater-hum levels of more than 500 microvolts.

These are conclusions of a limited investigation of heater hum recently made at the National Bureau of Standards and the study has yielded useful practical data for designing such amplifiers. Emphasis was on cataloguing heater hum characteristics of various tubes and circuit arrangements, rather than on investigating the causes of the hum.

Eleven tube types, in various circuit arrangements, have been studied so far. Included were single triodes 6F5 and 6SF5; dual triodes 6SL7, 7F7, and 5691; and pentodes 6J7, 6J7G, 6J7GT, 6SJ7, 5693, and 6SH7. In general, only 4 to 6 tubes of each type were checked, although tubes of several manufacturers were included wherever possible. Data were discarded for occasional individual tubes which, in showing wide deviations from the mean, were not believed representative.

Fig. 1: Levels of heater-induced hum in eleven tube types with bypassed cathodes in various amplifier arrangements. Vertical position of the tube on the chart indicates 60 cycle hum in equivalent microvolts at grid for several circuit variations



Circuits were varied with respect to cathode bypass capacitance, heater return tie point, heater return potential, and grid circuit resistance. The cathode resistor was either bypassed with a 50 μf capacitor or left unbypassed. Input grid resistance was either zero or 0.5 megohm. The heater return was either to one side of the heater, or through the adjustable arm of a 100-ohm potentiometer placed across the heater supply and adjusted for minimum 60-cycle output. Heater return potential was either to ground, to 45 volts positive, or to 45 volts negative. Hum measurements were made with various combinations of these circuit variations.

In the test set-up, the 60-, 120-, and 180-cycle hum components of the output of the amplifier under study were measured on a vacuum-tube volt-meter, using appropriate amplification and filtering. At the same time, wave form was observed on a cathode-ray oscilloscope. Gain was measured by applying a known signal to the grid of the test amplifier; hum level could then be expressed in terms of equivalent microvolts at the grid. Provision was made for switching from ac to dc heater supply for calibration and comparison.

To obtain the desired measurements of heater-induced hum, external ac hum was reduced to a negligible value, using recognized shielding precautions; heater leads were twisted and shielded and kept away from the grid circuit, which was also shielded.

Circuit components were based on median values given in manufacturer's manuals. Preliminary checks indicated that hum is not significantly affected by the usual variations in components—plate, screen, and cathode resistors, and cathode and screen bypass capacitors—required to match different load impedances.

The most hum-free amplifiers investigated so far at NBS used either of several triodes (6F5, 6SF5, 7F7, or 5691) or a pentode (5693), in a circuit including bypassed cathode, heater grounded through an adjustable potentiometer, and low grid impedance. Wide hum differences were found for different tube types, as well as for different circuit arrange-

in Audio Amplifiers

ments. Apparently, however, the 60-cycle equivalent input hum of almost any tube type tested, whether triode or pentode, can be reduced to 10 microvolts by suitable circuitry; and all of the triodes tested could be brought below 2 microvolts.

The NBS figures are for the 60-cycle components alone and are therefore not fully comparable with figures given in the literature, which generally include harmonics. The 60-cycle components were measured because of their importance in low-level power-frequency amplifiers, often required in instrumentation applications. Some of the low 60-cycle values measured at NBS were accompanied by harmonics no greater or even substantially less than the 60-cycle figure; in other instances the harmonics were many times greater than the 60-cycle component.

The general effects of the circuit variations were not unexpected. Without the cathode bypass condenser, hum was of course much greater; a sufficiently large bypass capacitor is obviously desirable for all low-hum applications. Return of the heater circuit through an adjustable potentiometer connected across the heater supply, when adjustment was optimum, reduced the hum to as little as 1/20 or even 1/50 of the initial value. Returning the heater circuit through 45 volts, either positive or negative but preferably positive, reduced hum somewhat in most cases. Increased grid circuit resistance tended to give greater hum in triodes, while in pentodes hum in general either showed no change or else decreased with increased resistance.

---

1. "Low Noise Miniature Pentode for Audio Amplifier Service", D. P. Heacock and R. A. Wissolik. TELE-TECH, Vol. 10, No. 2, Feb. 1951.
2. "Controlling Hum in Audio Amplifiers", L. T. Fleming (NBS). Radio and Television News, Nov. 1950, p. 55.

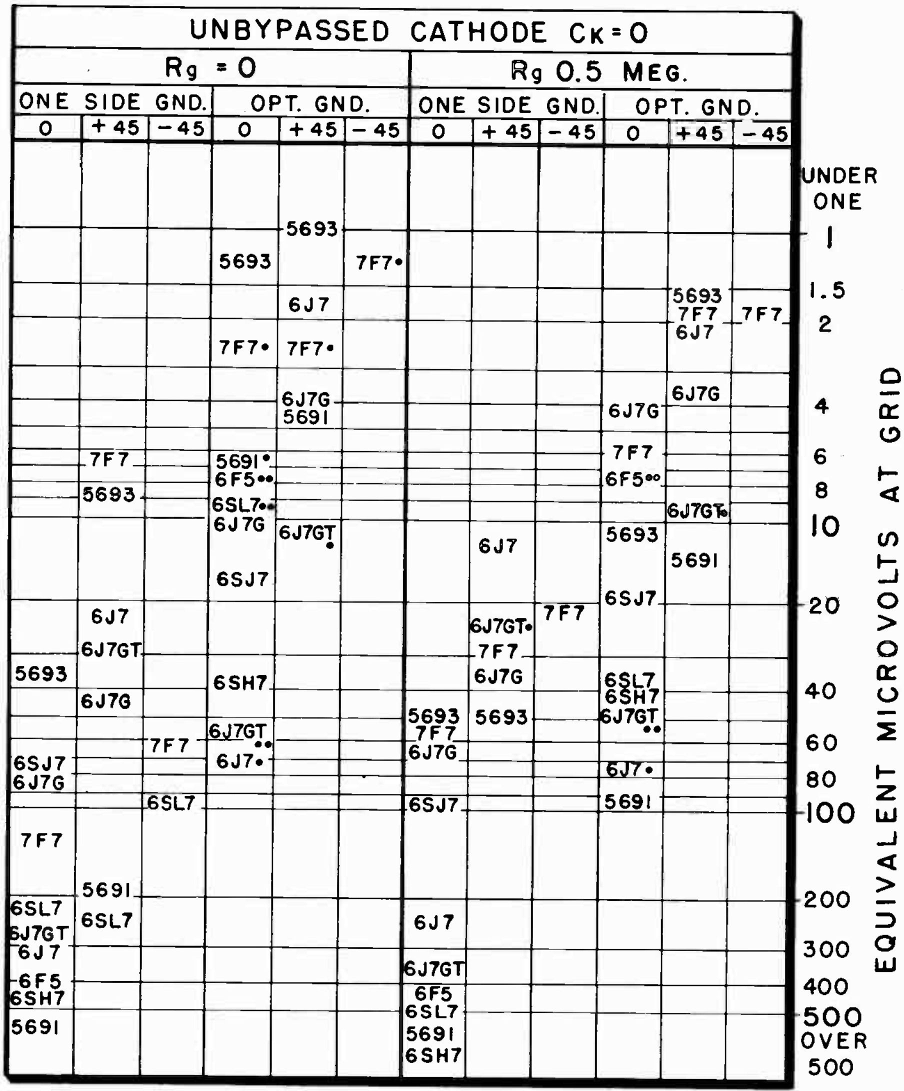
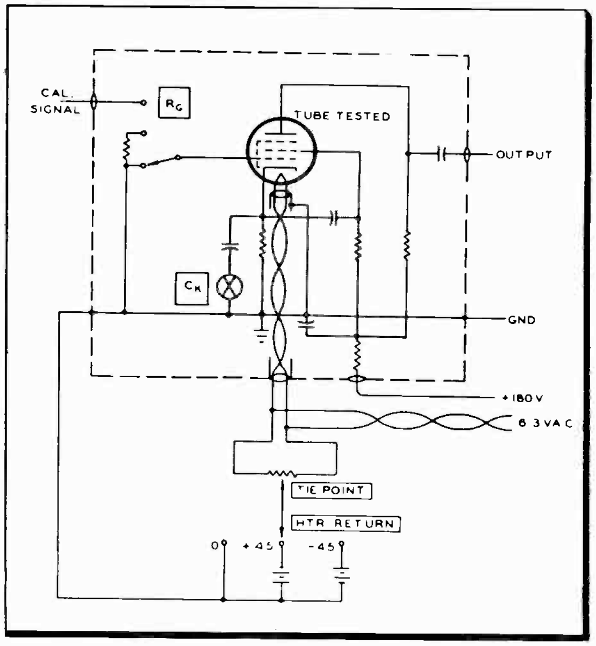
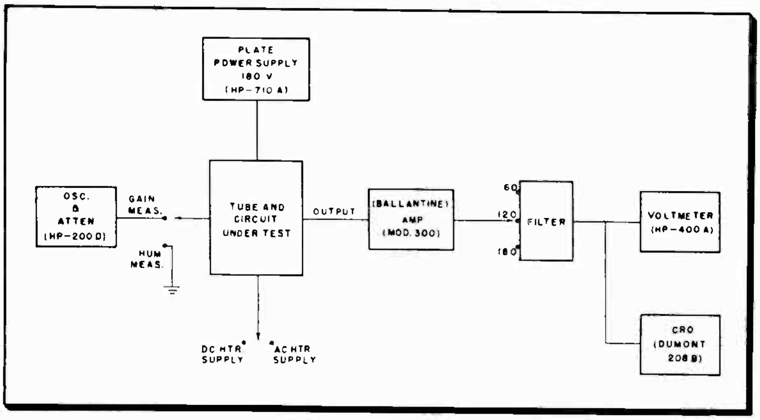


Fig. 2: (above) Chart similar to that shown in Fig. 1 except that cathode circuits are in unbypassed condition
Fig. 3: (lower left) Block diagram of complete arrangement for measuring hum level
Fig. 4: (right) Typical low-level amplifier circuit used in these measurements





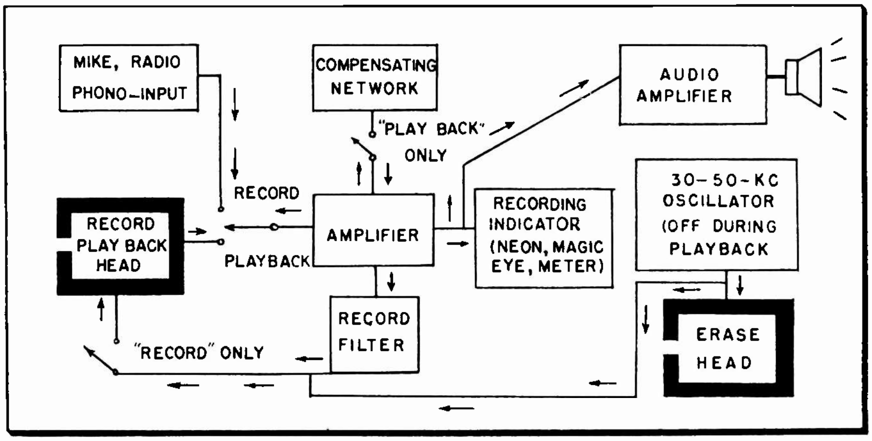
The Servicing and Maintenance

Part I of an Article Dealing With Principles and Problems of

By Charles Graham, Technical Editor

• Today tape recorders are becoming more widely adopted than wire recorders, even though a substantial number of the latter are still in use. The electronics for the two mediums are almost identical, and only the mechanisms show much dissimilarity. We will therefore consider tape recorders primarily, noting exceptions in some cases which apply to wire.

A magnetic recording consists of a medium which has been magnetized in accordance with electrical signals whose frequency and amplitude change to reproduce the intelligence (usually sound) it is wished to record. The best magnetic mediums have been found to be a certain type of steel wire (normally .004 inch diam.) and paper or plastic tape which carries a thin coating of ferrous oxides. The tape is ¼" wide and about .002 inch thick.



Fi2. 2. Block diagram of typical recorder. Some models incorporate erase in the other head.

Heads Do Three Jobs

There are three magnetic processes involved: recording, playback, and erasing. In most home and office recorders the playback and recording are accomplished by use of the same magnetic head.

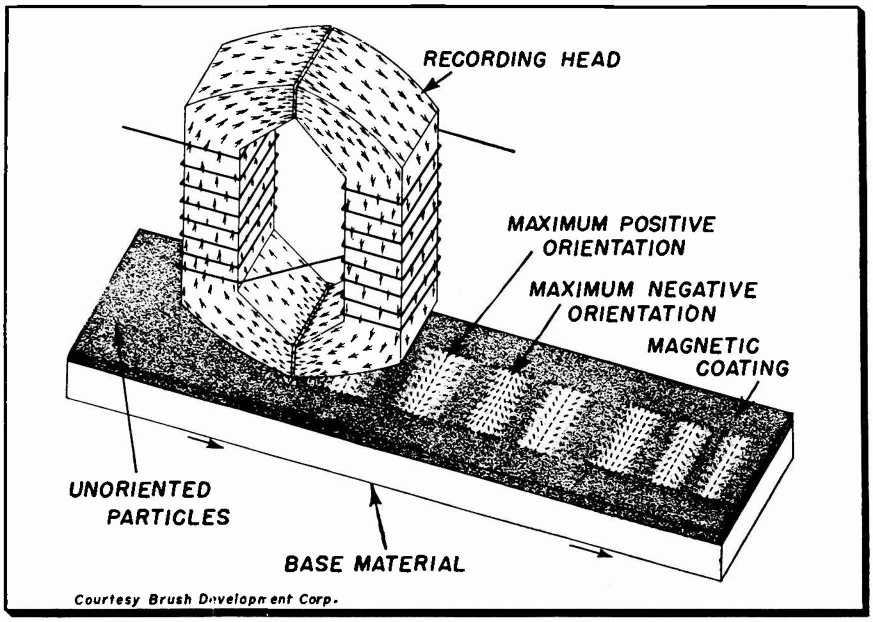
It is also necessary to move the magnetic medium, whether it is tape or wire, past the playback or recording head at a fairly constant speed. As the tape passes the recording head, currents from the amplifier induce varying magnetic poles in the tape. These magnetic poles are spaced closely together for sounds of high frequency and farther apart for sounds of low frequency. In additon, if the sounds being recorded are weak, then there are only a few particles of oxide magnetized, whereas, the areas of magnetic orientation are larger for stronger sounds.

When these areas of magnetically oriented oxides are pulled past the playback head they induce small voltages in the windings of the playback head, and these voltages are amplified and used to drive a loudspeaker, creating the sounds which made the original recording.

Erasing is accomplished by subjecting the recorded tape to a very strong magnetic field which wipes out previously recorded signals, or saturates the tape. This can be done either with a magnet, called a DC erase, or with an erase head similar to the record-playback head, with an AC current producing the AC erase. This leaves the tape quieter, and is most often employed.

There is one recorder which uses a permanent magnet to produce a sort of AC erase by arranging several poles of a magnet to give the effect of reversing the poles rapidly. In a few recorders, the erase and playback-record heads are combined into one head, with an E shaped lamination which has separate erase and playback-record windings wound on it. This type of head has two gaps in it, the wider, around .01" is the erase gap. These gaps are filled with soft, non-magnetic metal to insure that the tape does not catch in the gap. The smaller gap is about .0005" wide, and is for playback and recording. The AC current used to supply AC erase is usually about 30 to 50 KC, and is supplied by a beam output tube such as a 6V6 or 6K6, or in some recorders by a twin-triode like the 6SN7, in a pushpull circuit.

In recording, as the tape is pulled past the recording head, the particles of ferrous oxide, which have been unoriented, are magnetically arranged in place to form many small magnets, as shown in the drawing on the left. This is caused by the magnetic lines of force which are set up across the recording gap in the recording head. These magnetic lines of force are the result of the current in the recording head laminations, which current is in turn created by the recording amplifier. The currents required are fairly small, and a triode tube will supply the recording current easily. It is necessary to supply a small amount of AC bias to the recording head



Courtesy Brush Development Corp.

of Magnetic Recorders

Tape; Non-Mechanical Service Procedures Are Discussed

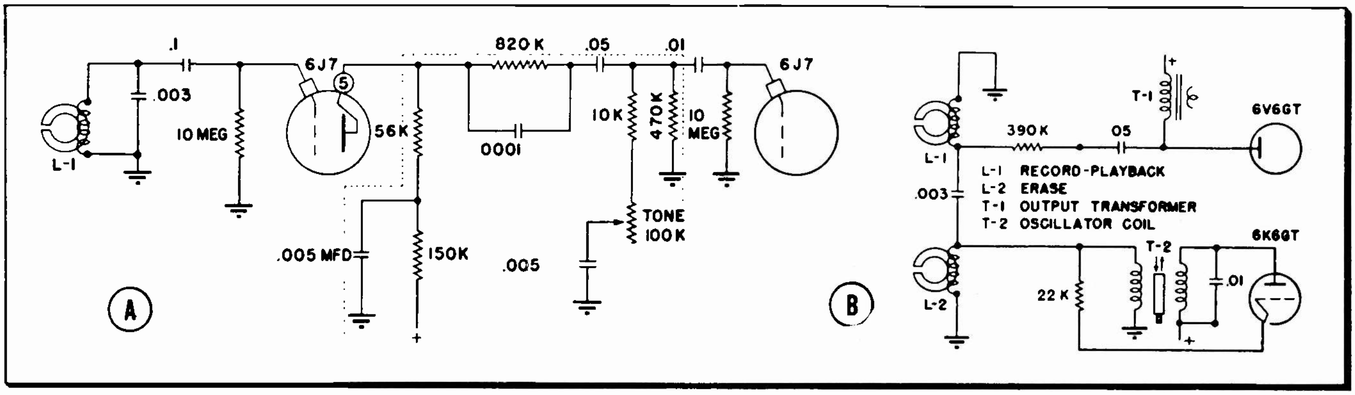


Fig. 3. Simplified playback circuit (A) and record-erase arrangement (B) taken from Revere model TR-200 tape recorder.

along with the recording current. This AC bias is usually a small portion of 30-50 KC alternating current, taken from the conveniently at hand erase circuit. The reasons for the AC bias are highly theoretical. However, it is easily demonstrable that without this so-called AC bias the recording will be so distorted that it will be hardly recognizable. The amount of AC bias used varies from one recording head to another, and from one tape to another. It usually is from 2 to 4 ma., and its adjustment is rather critical in getting good results from the recorder. Later we will consider means of checking the AC bias, and ways of varying it, where necessary.

Equalizing Networks

Due to the fact that magnetic tapes do not have a linear frequency response characteristic it is necessary to apply equalization at several points. The first equalization is done in the recording. The recording current is usually taken from the plate of a tube, so there is a recording filter network, consisting in most cases of one condenser and one resistor, connected between the plate of the recording amplifier output tube and the record head.

In playblack the tape is pulled past the reproduce, or playback head, which is now connected to the grid of a very high gain amplifier. Again equalization is applied. This time it is in the form of a condenser (usually around .002 to .004) which is intended to resonate with the inductance of the playback head to provide boost at around 5000 cycles. After amplification in one or two stages there is bass boosting also, to compensate for the loss of lows.

These equalizations are in addition to and separate from any form of manual tone control. Most recorders have tone control of the well-known high roll-off variety. This is never incorporated in the record circuit, but only in the monitor and playback circuits.

In figure 2 is shown a block diagram of a conventional home-type tape recorder. The audio amplifier is usually automatically disabled during mike recording so that undesirable acoustic feedback will not occur.

There are a large number of troubles which can occasionally arise in any piece of electronic equipment. The largest number of these are sufficiently similar to regular radio or audio amplifier troubles so as not to call for special comment. Therefore detailed trouble-shooting procedures which are identical with radio procedures will not be repeated here. However, the use of the supersonic (30-50 KC) AC bias and erase currents introduces a new element. As before stated, the amount of bias employed is not only rather critical if good re-

Troubleshooting Common Electronic Faults in Magnetic Recorders

Trouble	Symptoms	Remedy
I Records distorted and/or weak	No AC bias (30-50 KC) (measure bias E or I as outlined in text)	1. Substitute new tube in supersonic bias-and-erase circuit. 2. Measure DC volts (neg.) at grid of same tube.
II Records distorted (previous recording remaining on wire or tape)	No erase—or weak (only if AC erase is used. If magnet erases, omit II.)	1. Follow procedure for Trouble I, except insert 2, below, after 1, in I. 2. Check erase head for open, or short. Should read at least .1 ohm or more.
III Records, but slight sound remains from previous recording(s)	Insufficient bias or erase	1. If permanent magnet is used for erase, add AC erace circuit and head—manufacturer's data. 2. If AC erase, check for proper magnitude of both erase and record bias. Check waveform with 'scope.
	3. Check for shorted turns by comparing R of heads with known good heads (of same model—head design often varies from one production run to next.	4. Check with previously recorded tapes known not to be over-recorded (saturated)—or tapes from another machine. Also try another type or brand of tape.
IV Excessive hum	Determine whether hum is in circuit or is recorded on tape	If on tape, check power supply for humless B plus. If not in recording, check 1st stage—
	3. Add hum removal circuit to filaments. See text—also RTR, page 75, Aug., '51.	1. Try 2 to 4 new tubes in 1st stage. 2. Check lead dress of 1st grid, and of play head lead.

Servicing Recorders

sults are to be obtained, but that amount varies with different recorders and different makes of recording tape.

Badly distorted recordings can arise from the following causes associated with the supersonic alternating current.

1. Weak bias—tube not oscillating strongly enough.
2. No bias at all—tube or components bad.
3. No bias—or erase head burned out.
4. Too much bias—or poor waveform—often happen together.

The best place to test for proper AC bias is at the recording head itself. If the shop is equipped for TV work, an oscilloscope will be handy, and it can be connected right across the recording head. The advantage of using a 'scope, if the recording is distorted, is that the scope will not only measure the amplitude of the AC bias, but will show whether or not there is a good sine-wave shape at the recording head. *No shape other than a sine-wave is acceptable in the AC bias.* If the scope is used for TV work, the voltage calibrator should always be hooked to its terminal, so the shielded input lead of the calibrator, which is usually connected into the TV set to measure waveforms, is here connected across the recording head. The recorder is put in record position with no signal going to its input. The only signal then appearing across the recording head will be the supersonic bias. If there is no bias at all, check the supersonic oscillator tube and circuit to ensure that it is oscillating. In some cases it will be found that there is enough bias but that it is of the wrong frequency. Particularly if the frequency is too low, say in the audio range, annoying chirps, whistles, and distortion may arise. To check the approximate frequency of the AC bias, bridge the 'scope across the recording head and inject a high audio frequency into the input of the recorder. If 15 to 20 KC is used, it will be possible to compare this signal directly on the 'scope screen with the unknown bias signal. The amplitude of the 15 KC input would have to be kept low, of course, to permit observation on the screen of similar amplitudes of the two signals. Use the highest audio signal for comparison purposes which is available, and which is a convenient sub-multiple of the desired bias frequency.

If the frequency is radically off, almost always the waveshape will be poor also. This will be found to be due to a failure of some oscillator circuit component.

If the waveform is OK but the amplitude is less than the manufacturer recommends, a new tube is often the answer to the problem. In the trouble-shooting chart shown it will be noticed that the first step in checking for distorted and weak recordings is trial of a new bias and erase oscillator tube.

Another way to measure the AC bias, if a scope and calibrator are not at hand, is to insert a 10 ohm resistor in series with the record head, put the recorder in record position, and measure the AC voltage across the resistor. If the proper bias current at the head is 4 ma., then the voltmeter should read .04 volt. In some cases the manufacturer does not specify the bias *current* in the service literature, but instead gives the proper value of AC voltage at the plate of the oscillator tube or at the recording and erase heads. In such case, direct measurement can be made.

Often recorders come into the repair shop with a complaint of "hum". When this is a *correct* description of the trouble it is often found that it is merely a small amount of hum which was there all the time, due to the extremely high gain of the amplifier, but has only lately been noticed. This hum can usually be lessened by one or more of the following steps.

First the recorder is put in play position, with the volume control at maximum, with no tape. Let the motor run, and after removing the mounting screws from the power transformer, try changing its orientation slightly for minimum hum. (Some recorders have the power transformer mounted so that it can be rotated by simply loosening the screws.) If the power transformer is already mounted at an oblique angle, as in some late models, it can be assumed that it has already been oriented properly at the factory.

Examine the lead from the playback head to the first grid. In many cases this lead is protected with cotton or plastic and is grounded only at the grid return of the first amplifier tube. If the shield of this lead touches ground accidentally elsewhere it will often create bad hum. Also watch the dress of this lead. Its placement near filament, 110 V and other leads can often cause hum. Simple experimentation with redressing it may correct the trouble.

A first amplifier tube can often develop a slight amount of heater-to-cathode leakage. Though not nearly enough to show on a tube tester, in a high gain amplifier of this sort it can cause a lot of hum. Therefore the first check is to try at least two, and preferably four, new tubes in the first voltage amplifier, meanwhile leaving the volume turned up full, recorder in play position, with no tape.

Finally, hum in the first tube can be cut to an absolute minimum by installing a 100 ohm pot across the filaments, removing the filament winding centertap (if any) from ground, and grounding the arm of the pot. Adjustment of the arm is then made for minimum hum. Or, alternately, a small B voltage is applied to the first filament by using a voltage divider network across the B supply. Two ¼ watt resistors of 20 to 30 and 200 to 300 K will do.

Part II

• The radioman of today, it is often said, has to be an accomplished plumber, steeplejack, tinsmith, and cabinetmaker, in addition to his abilities in electricity and electronics. Certainly in the repair of recording machines his skill as a mechanic is called for as often as is his knowledge of the electron art.

Most recording machines are complicated electro-mechanical devices. So a brief examination of the mechanical operations which magnetic recorders must perform is in order, before we go after the faults which can arise in the performance of these operations.

The tape must be *transported* evenly past the recording, playback, and erase heads. The tape must be wound fairly closely on the *take-up* reel, and must unwind easily from the *supply* reel, without *spilling*. In addition, it must be possible to stop all three of these operations at once, smoothly and quickly, without breaking or tearing the tape (which is made to withstand a pull of from five to eight pounds). Finally, it must be possible to start these three movements quickly and smoothly, either in the normal, forward direction, or in reverse.

At the same time that the tape is being moved forward, stopped, or run in reverse, the heads (most often *two*: record-playback, and erase, but sometimes *all-in-one*, and in a few recorders, *three* separate) have to be in close, but not binding, contact with the tape, and they must in some machines even shift vertical position.

It is difficult to design a machine which will go through these various motions, and still make the machine foolproof, easy-to-operate, and cheap to produce. Design engineers have shown a great deal of inventiveness in producing transport mechanisms to do these jobs. But nevertheless these machines must sometimes come into the shop for repair or overhaul due to their necessary complexity.

The tape is pulled past the recording (or playback) head at a very steady even speed. Usually this is 7.5 *inches-per-second*, though many home machines have a speed of 3.75 *ips*, or allow a choice of either speed (professional machines are usually 7.5 and 15 ips, or 15 and 30 ips, for extreme high-frequency response and optimum signal-to-noise ratio). The tape is pulled by a metal or cork-covered capstan which is attached to a fairly heavy flywheel. The flywheel is used to smooth out small rapid periodic variations in the speed of the capstan. When these variations are present, they cause *flutter*. The flywheel is driven by an electric motor,

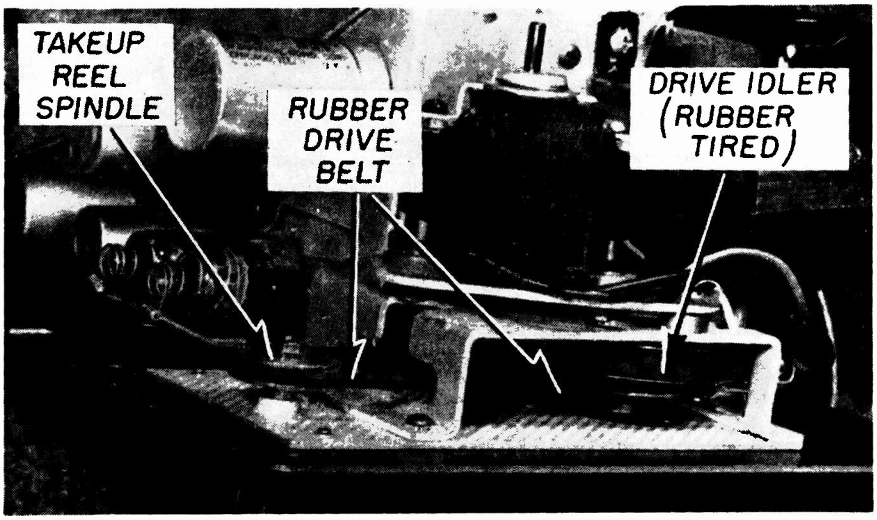


Fig. 1. Below is bottom mechanical assembly of Ampro machine. Motor is atop drive housing.

either coupled to its shaft through a pulley-and-idler combination, or by means of a rubber belt.

Since the tape moves at a constant speed, the *take-up* reel must take up a constant linear amount of tape, but it must take it up with a constantly increasing diameter which means a constantly decreasing rate of turning. Meanwhile, the *supply* reel must pay out the tape at a constant speed, but from a constantly decreasing diameter, which requires that *it* turn at a constantly increasing speed. And when the transport goes in the reverse direction, the roles of the two reels (!) are reversed.

The only way which has been found to accomplish this variety of functions is to keep the tape moving steadily, and let whichever reel is taking-up at the moment *slip*, while the reel presently pulling *drags*. The tensile strength of the tape is therefore seen to be a limiting factor in determining how much slipping or dragging pressure there is between each reel and the capstan. The most expensive recorders use separate electric motors for the capstan drive, take-up reel, and supply reel. A slight DC is applied to the field of the supply motor, and this provides light but constant braking, or drag. For smooth quick stopping, a stronger DC is applied to the fields of all motors. Unfortunately this is an extremely expensive way of doing the job. Mechanical clutches are used on most home recorders, and if not allowed to go too long without adjustment, and if not mis-adjusted, they function well.

These mechanical clutches are usually felt clutch plates, or cloth or rubber (slipping) drive belts. The felts must occasionally be cleaned or replaced, and the belts become smooth or stretched after protracted use, and so require replacement.

The record-playback head and the erase head often get dirty, due to the collection of oxide (recording material) from the tape. Cleaning of the heads is the first of all standard maintenance procedures.

Alcohol* and a brush (or drugstore "Q Tips") are required for cleaning the heads and other parts. The drive capstan should be cleaned, although it will not require attention as often as the heads. Care must be exercised not to injure the capstan with excessive cleaning. Early recorders had capstans covered with cork, and special care must be taken with these. Today most machines use idlers having neoprene rubber surfaces, and capstans are precision ground.

Most important maintenance is keeping the mechanism clean. Many of the mechanical motions are transferred by neoprene idlers and pulleys, which does produce a certain amount of rubber particles and dust. This can get into bearings and cause wow, flutter, and in some cases even stalling, if not cleaned out after excessive periods of use.

The diameters of the various pulleys, idlers, flywheel (if it is a bearing surface) capstan, and drive shafts, are all critical. They are generally ground or turned down in production (not simply *cast*, as are similar parts on many phonographs, which are an entirely different class of mechanism) to tolerances of one or two thousandths of an inch. This means that sandpaper, files, or other abrasives are strictly forbidden from touching any bearing or driving surfaces. There is no reason for the serviceman to treat these surfaces at all, except to clean them of grease or dirt.

Where a belt is used to transfer power from motor shaft to take-up reel, the belt may after a time become dirty and allow too much slippage, or it may bind. Chemical cleaning of the belt may be attempted, but replacement is recommended. When such items are ordered from the manufacturer, it is wise maintenance procedure to order two belts even though only one may be needed at the moment. (Manufacturers' charges for these parts are nominal, ordinarily.) Thus one is prepared the next time the same difficulty crops up.

If a recorder has not been dropped or otherwise mishandled, there is little likelihood that any mechanical work other than cleaning or replacement of idlers or belts will be required. When real damage has been done, such as the warping of the main motor board, bending of drive shaft, injuring of idler or pulley bearing surfaces, then it is best to return the mechanism to the manufacturer or his authorized factory maintenance center for rebuilding.

Manufacturer's service notes are very detailed concerning any mechanical repairs which the maker deems OK for the serviceman. In the absence of specific instructions, no mechanical work should be done on tape recorders other than cleaning and replacement of worn idlers, belts, felt brakes, or clutch faces.

Felt brakes are used in most recorders to stop or to slow down the take-up and supply reels. When it is necessary to replace these, they may be removed with cement solvent and new ones reglued in their place. On some machines felt clutches are used which consist of large felt pads glued to metal plates. These fit against other, matching, metal plates. The pressure of the felt pads against the plates is varied, depending on whether slipping or stopping action is desired.

The accompanying chart of common mechanical difficulties will serve as a guide in the absence of manufacturer's service data on the specific recorder involved. In all cases, the

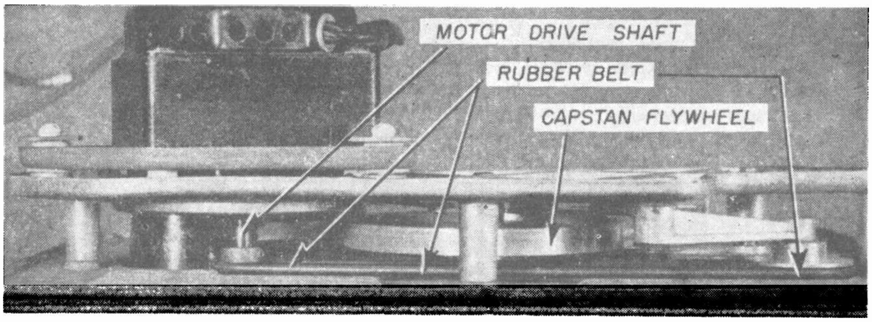


Fig. 2. In the Eicor mechanism above is shown the rubber belt which transmits motor force to takeup reel and capstan. Maintenance of proper belt tension and friction is important.

---

*Carbon tet is OK for cleaning heads. Some types of rubber are affected by carbon tet, however, so alcohol is recommended.

recommendations of the manufacturer should be followed carefully.

A few tape machines have unfortunately been put on the market in which some of the parts were not within the designer's tolerances, with the result that a small percentage of machines in use have flutter troubles which no amount of cleaning and adjusting can correct. In such cases, the makers are usually glad to receive information on the difficulties and will cooperate in taking care of the trouble by fixing the mechanisms at the factory. A word of caution, however: never send a machine back to the maker without first writing to request authorization, disassembly instructions (in some cases they will want only the mechanism, while in others the entire machine must be shipped), and packing instructions.

There are two ways of winding tape on the reels, and so there are two methods of threading the tape onto the mechanisms. Most machines today use the "A" wind, in which the oxide coating faces in *towards* the center of the reel, but a few still use the "B" wind. In the "B" wind the magnetic oxide coating (the duller side) faces *away* from the hub.

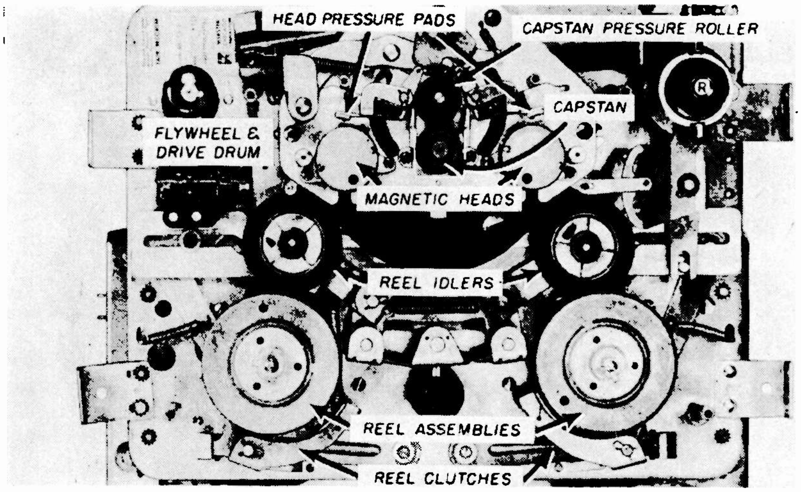


Fig. 3. Instantaneous dual track design of Webcor recorder uses symmetrical setup of reel assemblies, drive idlers and heads, which function both in play-record and erase.

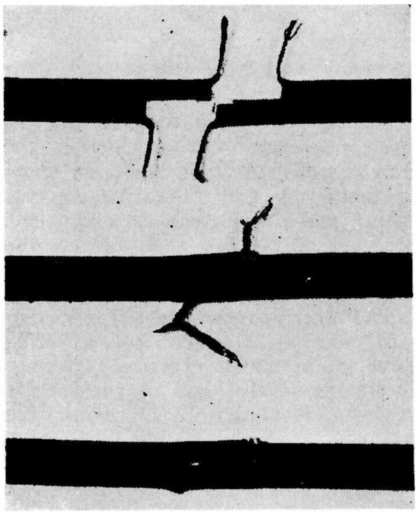
Troubleshooting Common Mechanical Faults in Magnetic Recorders

Trouble	Cause or Symptoms	Checks and Remedies
I. Distorted playback	Sounds "slow" or "sick" Sounds weak or uneven in volume	Check with tape made previously, known to sound OK. "Flutter"—clean all bearing and driving surfaces as mentioned in text. Ensure no parts are worn or binding. Dirty play-record head—clean. Tape not making good contact—guide pins or rollers bent—pressure pads worn, bent, or loose.
II. Distorted recording	Previously recorded tapes play OK, present ones sound distorted	See other chart, page 79, Oct. RADIO & TELEVISION RETAILING—II—bias weak or absent. Tape needs pre-run—sticks on reel, failing to unreel smoothly.
III. Insufficient erase	Previous material stays partly or wholly on	See other chart—part III—Dirty erase head (if magnet, old, weak). Erase head not making good contact with head.
IV. Poor response	High frequencies weak or uneven but speed OK	Play head dirty—picking up dirt, grease, dust, from tape. Or play head worn badly. See part III, 2 other chart—check for excessive erase current.
V. Tape moving too slowly "Wow" or "Flutter" Tape breaks at capstan Tape fails to move, or fails to takeup properly	Check with previous—OK recording "Wow is periodic speed variations a few times/sec. "Flutter" is same, but many times/sec. Power on, motor running	Too much or insufficient pressure of pads or pinch rollers or wheels against tape. Takeup reel dragging—check clutch pressure and/or surface.. Capstan worn or binding. Motor shaft binding. Also check No. I, above. Supply reel sticking, takeup reel or clutch worn or oiled; drive belt or pulley oiled or badly worn.

SHOP HINTS

Twin-Lead Splices

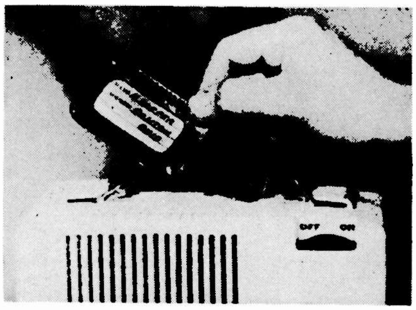
From Arthur Davis, New York City: The best rule for splices in TV lead-ins is not to make any as they invariably result in a trouble point, due either to a poor impedance match (causing line reflections) or a rusted, intermittent or open connection (resulting in signal losses, noise and flashes, or lack of signal). If you must make them, however, try to preserve the wire spacing (so as to maintain the impedance) and make a good, clean, secure connection. I use a staggered splice to achieve this result, as shown in the picture. The stagger is cut into one end, and then matched (in reverse) on the other piece.



Then the leads are twisted together. At this point, the twin-lead is back in its original shape again. I then trim off the excess. As shown in the third view, the twisted leads were soldered, and the hot iron used on the plastic to melt it over the exposed leads. If you don't have the time or facilities to use an iron (as for instance, outdoors), you can spray the connections with a plastic spray such as Krylon, or tape with one of the plastic electrical tapes. When I use tape, I try to keep it down to a minimum, as I believe too much tape affects the signal.

Goodwill on Portables

Whenever a portable radio is repaired, or batteries installed, a luggage name tag holder is attached to the handle of the portable, with the owner's name and address written in. In this way the customer gets a permanent identification tag which is at the same time a servicing re-



minder, for the dealer's name is also imprinted on the tag, along with his telephone number and address. *H. Leeper, Canton, Ohio.*

How to Install TV Towers in Fringe Areas

Step-by-Step Explanation of How to Get Them Up So They'll Stay Up

This detailed explanation covers proper mounting of the base; number, size and installation of guy wires, raising the tower, securing and plumbing the tower, mounting of rotators where used, proper grounding & other installation techniques.

• After the antenna has been selected, the most important problems in a fringe area television installation are those of getting the antenna as high in the air as possible—and making it stay there! Inexpensive masts made of thin-wall conduit or dural tubing are widely used for antenna supports in areas where heights of thirty feet and less give satisfactory reception, but their flexibility makes the erection of longer lengths difficult. Rigid towers of uniform triangular cross section, although more expensive, are more easily handled during erection and most types are strong enough to be climbed if antenna repairs become necessary. Self-supporting towers of the windmill variety are often used in locations where limited lot space does not permit use of guy wires. This article takes up the installation of guyed towers.

Mounting the Base

To insure that the guyed tower or mast will withstand winter winds and icing, a properly-designed base support and system of guys must be provided. In resisting the force of the wind, tension is developed in one or more guy wires, resulting in a downward force against the base of the tower which adds to the dead weight of the tower itself. Other things being equal, the amount of tension in the guy wires depends upon their placement with respect to the tower, and as shown in Fig. 1, may be minimized by attaching them at equal angles around the tower and as far from its base as possible. Care should be taken in choosing locations for guy wire anchors. Where screw hooks set in an ordinary roof are to be used as anchors, it is essential that they be set in rafters, as sheathing has very little holding strength. If the rafters cannot be located by measurements or by sounding, it is best to obtain the owner's permission to drill small test holes, which are immediately patched with roofing compound. If more than one set of guys is to be anchored in this manner, it is well to provide a separate screw hook for each guy wire, allowing sufficient separation between screw hooks to avoid splitting the rafter. If the guy wires have been properly located, most towers may be supported safely under almost any weather condition by one set of 6-20 or 6-18 steel guy wires for each twenty to thirty feet of tower height. Smaller guys at more frequent intervals are recommended for pipe masts, to avoid buckling. Construction of the base on which the tower or mast is to be mounted varies greatly from one installation to another. In all cases, however, the base should be capable of supporting several times the weight of the tower and antenna.

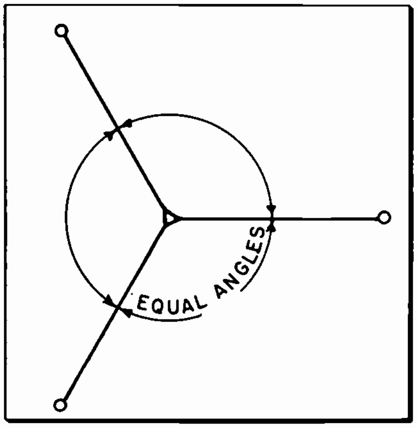
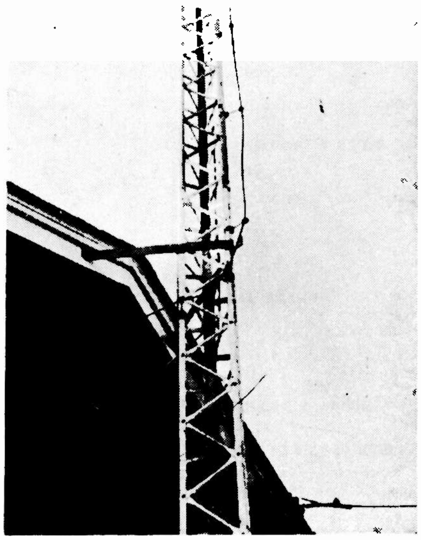


Fig. 1: Guy wires shown looking down at the top of the mast. If angles shown are unequal, wind blowing into the greatest angle will produce the highest stress in the guy wires. The distance from the guy wire anchor to the base of the tower should be about ¾ of the height of the tower at the point where the guy wire is attached. If this distance is less than ½ the height, use stronger guy wire and anchors. For recommended sizes of guy wire, see text.

Except in severely crowded locations, moderately high towers are most easily assembled complete on the ground, then erected with the aid of a hinged base and a boom, as shown in Fig. 3. After all sections have been bolted together and inspected for loose rivets, poor welds, and other defects, the completed tower should be bolted to a hinged base which is fastened securely to the roof or foundation on which the tower is to be erected. Support the free end of the tower on a sawhorse or box while the antenna, lead-in, guy wires, and stand-off insulators are assembled to it. If a motor is to be used to rotate the antenna, it should be tested before being attached to the tower to avoid the complications which arise from finding it improperly wired or defective after the tower has been raised. After testing, the motor should be left in its extreme counter-clockwise position and the antenna attached in such a manner that it will be pointing north after the tower has been erected. If the motor is geared to turn the antenna at one r.p.m. (most antenna rotators are), the second hand of a watch may be used as a direction indicator after the tower has been erected by starting clockwise rotation of the antenna from the

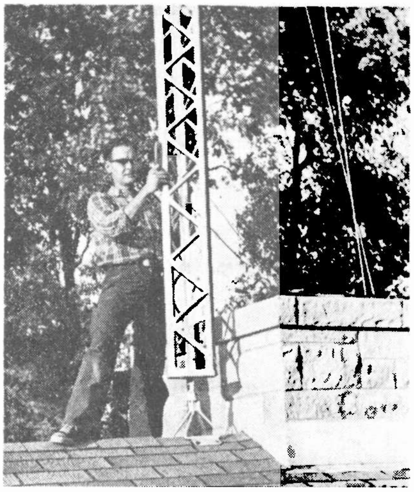
Fig. 2: When towers of up to 30 feet in height are installed next to a building, a single bracket attached to the gable or wall at a height of fifteen feet or more will take the place of all guy wires.



counter-clockwise stop at the instant the second hand passes zero.

It is important to determine in advance the length of the back guy wire in the top set. If this guy is cut to length and attached to the tower and to its anchor before the tower is raised, it will become taut and stop the tower as soon as the tower has been pulled into an upright position. The length of the guy wire may be calculated by any one of several methods, one of the easiest being by the use of a table of squares and square roots. (See Table I) The remaining two top guys should be pulled tight and fastened to temporary anchors on either side of the tower in line with the hinge pin in the tower base. These two guys act to steady the tower and prevent it from falling sideways during erection. Lower sets of guys, if used, should be cut to length and attached to the tower at the proper heights, then coiled and tied temporarily to the tower at a height which will be accessible from the ground after the tower has been raised.

Fig. 4: Helpers adjust guy wires as tower is plumbed with a hand level.



The actual erection of the assembled and rigged tower is begun by attaching a boom at a ninety-degree angle to the base of the tower and guying the boom if necessary to prevent it from being pulled sideways. A sturdy ladder may be used without side guys as a boom for the erection of small towers. A rope is tied to the boom and then to the tower at a distance from the tower base approximately equal to the height of the boom. To avoid climbing the tower later to retrieve this rope, a slip knot may be tied in such a manner that after the tower has been raised, the free end of the rope will be within reach of a man standing on the ground. Two men, one to push the tower up as far as possible by hand, then steady it as it goes up, and another to pull on the rope, can raise light-weight towers of at least forty feet in height. A block and tackle is helpful for raising heavier or higher towers. After the tower has been pulled upright, the man holding the rope can steady it against the pull of the back guy wire while his helper carefully moves the other two guy wires one at a time to their permanent anchors. The free ends of the lower sets of guy wires, which were temporarily fastened near the base of the tower, may now be attached to their anchors. To prevent kinking of the back guy wire while the tower is being raised, carry the mid-point of the wire as far as possible from the tower and attach a sliding weight to it. As the tower is raised, the weight will be dragged along, maintaining enough tension to prevent kinking the wire. When the tower is pulled erect, the weight will slide down the wire to the anchor, where it may be easily removed. The tower should be plumbed by adjusting the guy wires, taking care that the final guy wire tension is no more than that necessary to prevent swaying.

Certain makes of conical antennas have been found to lose elements due to fatigue cracks developing near the clamp as the result of vibration and strumming in the wind. It is well to

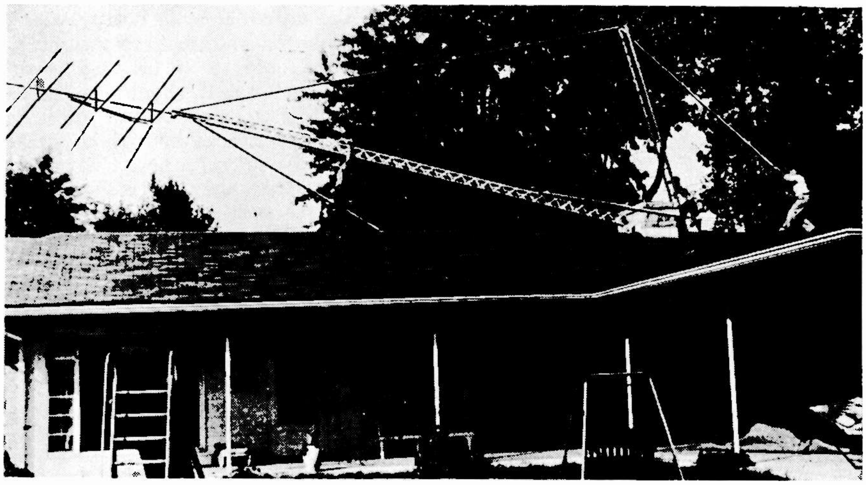


Fig. 3: The tower ready for raising. Below, the drawing shows the tower supported on a sawhorse as described in the text, where the other notes on the drawing are also more fully explained. The photo above shows the same situation a few minutes later, with the tower on the way up. Helpers are holding guy wires to keep the tower from falling sideways as it is raised. In the photo, a ladder is being used as a boom pole, and a direct pull is being exerted by the installer instead of a block and tackle as shown in the drawing.

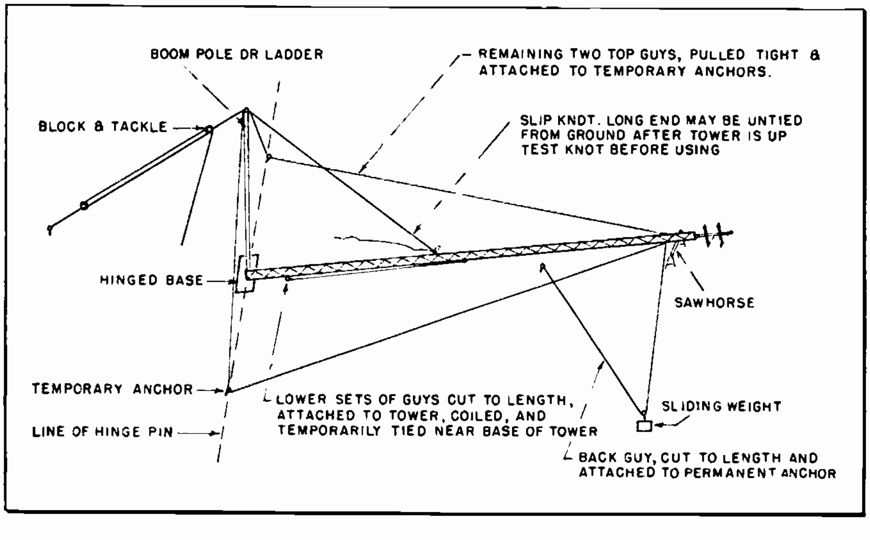
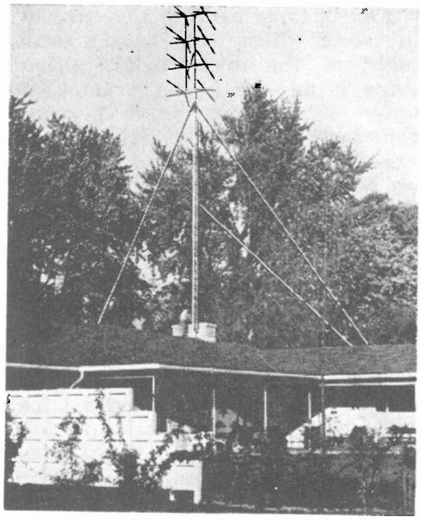


Fig. 5: The complete installation. A separate conductor should be run to a good ground for lightning protection. Grounding a guy wire endangers the mast, should that guy wire be damaged by lightning.

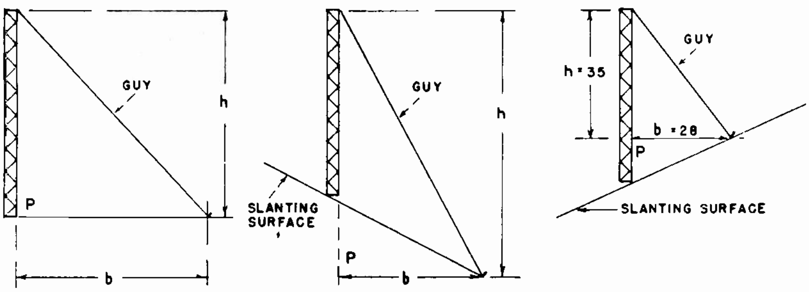


mount such antennas six or eight feet above the highest set of guy wires to permit a small amount of unrestrained motion. Many types of antennas make a roaring noise like that of an airplane under certain wind conditions. To avoid service callbacks, be sure to plug the top of the antenna mast with a large cork, and either place corks in the ends of the antenna elements or flatten them with pliers.

Towers and masts which rise more than a few feet above the rooftop should be protected against lightning damage. In most locations, a suitable grounding system may consist of one continuous length of #4 copper wire fastened to the base of the tower and brought down to a cold water pipe or an eight-foot ground rod. Electrical codes prohibit the use of soldered joints at any point in a grounding system: use clamps instead. A useful tool for driving ground rods may be made from a short length of one-inch pipe by fitting a pipe cap on one end. Under no circumstances should the #4 copper ground conductor be omitted and the guy wires grounded instead—a lightning stroke might damage one or more guys, leaving the tower unsupported.

Men working on rooftop installations should wear sneakers or crepe-soled shoes, both to insure safe footing and to prevent damage to the roof. One of the surest ways to incur customer ill-will is to leave his roof in a leaky condition. Much trouble from this cause will be avoided if a thorough inspection of the roof covering is made just before leaving the roof, and all damage carefully repaired. It is well to call existing leaks to the customer's attention, both as a service to him and as a protection to one's self.

The installation pictured on these pages was made in Kokomo, Indiana. WFBM-TV, Indianapolis, is about 50 miles distant, while other stations received here are located in Chicago, Cincinnati, Dayton and Milwaukee. All of these cities are over 120 miles distant. "Economy-minded" customers who do not care to "fish" for distant stations, are usually given a channel 6 Yagi or a 4-element conical antenna permanently oriented for WFBM-TV. For those customers who desire more programs to choose from, it has been found fairly successful to install an 8 element (4-stack) conical antenna and a rotator atop thirty to sixty feet of tower. Insofar as the location in Kokomo is about equidistant from and on a line connecting Chicago and Cincinnati, co-channel interference is a limiting factor on long range reception, the installers say.



TOWER ERECTED ON LEVEL SURFACE

GUY WIRE ANCHOR LOWER THAN TOWER BASE

FINDING LENGTH OF GUY WIRE

Table I

CALCULATING LENGTH OF A GUY WIRE

A guy wire is to be attached to a tower as shown. To find its length, measure the distance from the anchor to point p, which is level with the anchor and on the tower (or directly below it, if the anchor is lower than the base of the tower). Call this distance b. Choose the point at which the guy wire is to be attached to the tower and find the distance h between it and point p.

The length of the guy wire is equal to $\sqrt{b^2 + h^2}$. In this example, find $b = 28$ in the "No." column of the table and opposite it read $b^2 = 784$. Similarly, find $h^2 = 1225$. Adding, $b^2 + h^2 = 784 + 1225 = 2009$. In the "Square" column of the table, locate the number nearest 2009, which is 2025. Opposite 2025, read 45, the length of the guy wire. Be sure to allow additional wire for splices at the ends.

TABLE OF SQUARES

No.	Square	No.	Square	No.	Square	No.	Square	No.	Square
10	100	21	441	32	1024	43	1849	54	2916
11	121	22	484	33	1089	44	1936	55	3025
12	144	23	529	34	1156	45	2025	56	3136
13	169	24	576	35	1225	46	2116	57	3249
14	196	25	625	36	1296	47	2209	58	3364
15	225	26	676	37	1369	48	2304	59	3481
16	256	27	729	38	1444	49	2401	60	3600
17	289	28	784	39	1521	50	2500	61	3721
18	324	29	841	40	1600	51	2601	62	3844
19	361	30	900	41	1681	52	2704	63	3969
20	400	31	961	42	1764	53	2809	64	4096
								65	4225

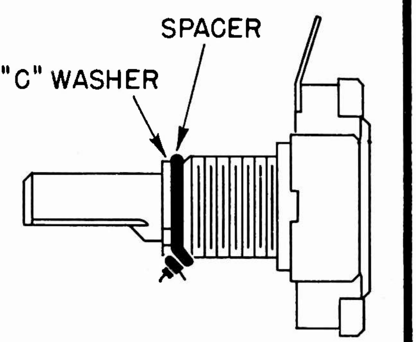
Tips for Home and Bench Service

Noisy Volume Controls

Noisy controls can many times be temporarily repaired and freed from the "scratch" by applying more pressure from wiping arm to carbon ring. This may be accomplished by placing a spacer between the "C" washer and the body of the control. A good spacer can be one strand of AC linecord wound once around the shaft and then the ends twisted. A slight pull on the shaft of the control will reveal sufficient space for this repair operation.—*David Allen, Allen's TV, Radio & Appliance Co., 11034 So. Vermont Ave., Los Angeles, Calif.*

TV Loudspeakers

A job that can make the customer happy and the serviceman prosperous is to put a better speaker on the TV set. Usually the set has a small one, and often poorly placed.



A great improvement can be effected by installing a large, good quality speaker in an appropriate baffle. Many TV sets, however, have a field coil speaker. The best thing to do is to leave this speaker on the chassis (which saves you the trouble of redesigning the power supply) and install a switch in the voice coil leads so that either speaker can be used. Putting in a plug for the new speaker completes the job. The beauty of this arrangement is that, when servicing is required, the big speaker can be left in its cabinet, and the little speaker can be used during repairs.

Time Saving Pointers on

How to Diagnose and Repair Intermittent,

By Solomon Heller

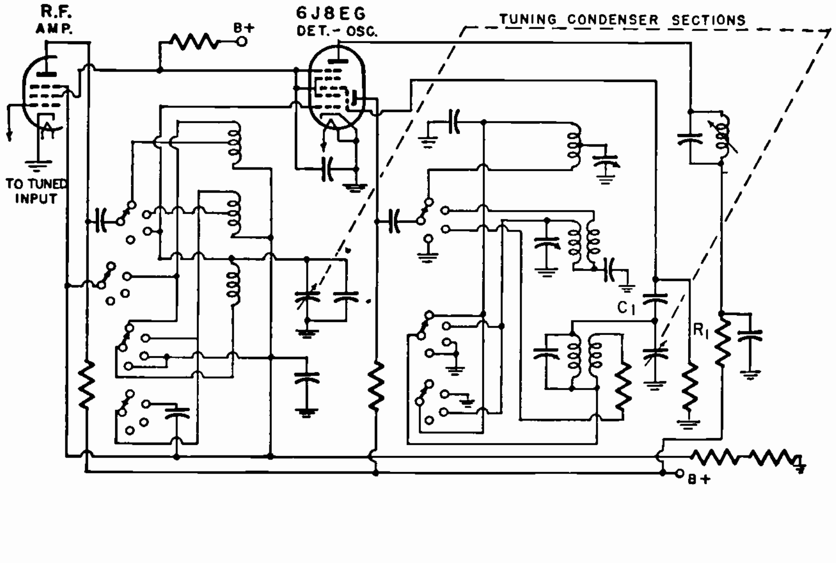
• For many servicemen, the oscillator section of the broadcast receiver has always been the most difficult to understand and troubleshoot. The reason may lie in the apparent complexity of oscillator circuits, particularly when multi-point band-switches are present. Many servicemen who have read and grasped discussions of simplified oscillator circuits are apt to get lost in the underbrush of an unfamiliar, unsimplified oscillator diagram (see Fig. 1).

This article will not pretend to remove completely the thick blanket of fog from the subject. We will, however, attempt to punch enough holes in it to make oscillator servicing somewhat simpler.

Oscillator Fundamentals

We base our article on the premise that an oscillator stage may frequently be serviced, even when the exact details regarding its operation are unknown. It is often enough to understand that: 1—All oscillators used in broadcast receivers generate a signal which, when mixed with the incoming RF signal, produces the intermediate frequency. 2—Feedback of a correctly-phased signal voltage from the output to the input circuit of the oscillator is necessary. When transformers are used for feedback, their leads must be correctly connected, so that the signal fed back is in the proper phase to sustain oscillation. (Reversed leads will cause oscillation to cease.) 3—A tuned circuit is generally present in the oscillator grid. 4—A grid-leak bias of the correct amplitude is present at the oscillator grid when the stage is functioning normally. 5—The plate voltage on the oscillator tube must be adequate to sustain oscillation. With this basic information, a fairly intelligent attack on almost any oscillator may be made.

Fig. 1—An oscillator circuit of the simpler sort. Far more intricate-looking circuits exist. Part of the RF amplifier and the mixer is shown in this diagram. Set model number is Philco Model 41-758.



Standard Checks

The first problem that must be faced is: When should trouble in the oscillator be suspected? The presence of any of the following common symptoms should focus suspicion on the oscillator:

1—Inoperation, accompanied by high sensitivity in the set. Background noises, crackling sounds and hisses are noticeably present.

2—Reception of only one station at the low end of the broadcast band. Reception of this station is not eliminated when the stator of the oscillator tuning condenser is shorted to the rotor.

3—Reception of stations at the high end of the broadcast band, but not at the low.

4—Intermittent appearance of any of the above symptoms.

5—Set's ganged tuning condenser needs frequent resetting.

6—No station, or one station, is received; a modulated i-f signal applied to the antenna input of the receiver is heard in the speaker.

The next problem is, how should the oscillator be checked? One or more of the following methods may be employed, depending on the symptoms: a) voltage tests, b) resistance tests, c) frequency or alignment check, d) component substitution checks.

When no station, or only one station is received, a grid-leak voltage check of the oscillator will quickly reveal whether this stage is the source of the trouble. If the correct grid-leak bias is present, the oscillator is functioning normally. This test, it should be noted, tells us nothing about the frequency at which the oscillator is operating. A simple alignment check will, however, clear up the latter point.

Several pointers regarding the grid-voltage check just referred to are worthy of mention. First, only a vacuum tube voltmeter using an isolated DC probe will give an accurate oscillator grid voltage reading. Since servicemen sometimes use other types of voltmeters for this purpose, it may be helpful to consider the matter in detail.

Measuring Bias

If a 1000-ohm-per-volt meter, or a 20,000-ohm-per-volt meter, were employed, two undesirable effects would occur when the voltmeter leads were applied between the oscillator grid and ground: 1—The relatively low input resistance of the voltmeter would reduce the impedance between grid and ground of the oscillator (see Fig. 2). The resultant loading of the oscillator tuned circuit would lower the "Q" of the latter, cutting down the amplitude of the oscillator signal or even eliminating oscillation completely. 2—The leads employed would introduce a certain capacitance (represented by C_L in Fig. 2) in shunt with the oscillator tuned circuit. Detuning of the latter would result.

To prevent effect No. 1, a VTVM is employed. The input resistance of a VTVM is generally in the neighborhood of 10 megohms. 10 megohms will not appreciably decrease the relatively low grid resistance—20K to 100K—with which it is placed in shunt.

To prevent effect No. 2, a 1-meg isolating resistor is inserted in series with the DC probe of the VTVM (see Fig. 3). In many cases, the resistor is already present in the probe, and need not be added by the serviceman. The shunt capacitance of the "hot" meter lead is isolated from the oscillator tank circuit by the 1-meg resistor, and is thus prevented from detuning this circuit.

Servicing Oscillator Stages

Inoperative and Drifting AM RF Oscillators

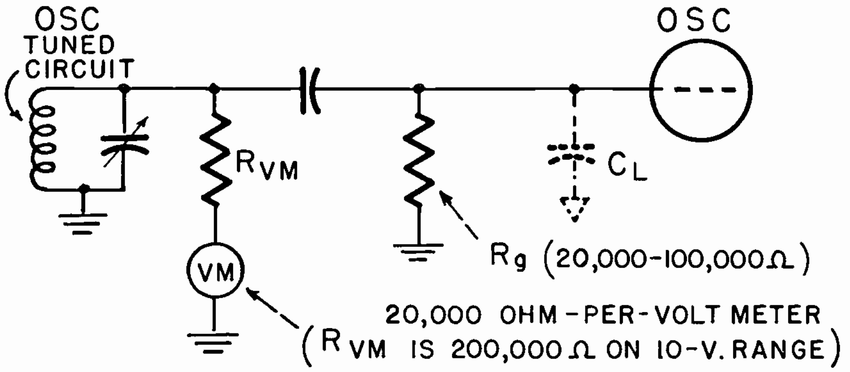


Fig. 2—Using a voltmeter with a relatively low input resistance will load down the tank circuit. If Rg is 100,000, and Rvm, the internal resistance of the meter, is 200,000, the effective value of Rg becomes about 67,000 ohms.

When no VTVM is available, the oscillator grid voltage may be indirectly checked by inserting a milliameter in series with the grid-leak resistor, as shown in Fig. 4. By measuring the current (in amperes) and multiplying it by the grid resistance (in ohms), the oscillator grid voltage may be obtained.

A negative voltage reading somewhere between 5 and 25 volts should be present between the grid of the oscillator and ground. The average voltage for an AC superhet is roughly 15; for an AC-DC receiver, about 10; for portables, 7-10. The reading will vary as the oscillator tuning condenser is rotated throughout its range; this is normal. The highest oscillator voltage will generally be measured at the high-frequency end of the band. There should be no point, throughout the range of the tuning condenser, at which the grid voltage drops to a very low value, or zero, if the circuit operation is normal.

If no grid-leak voltage is measured, the following tests (among others) should be made: 1—Substitute an oscillator tube known to be good for the one present in the set. 2—Check plate and filament voltages of the oscillator stage. 3—Check for open or short in tuned circuits. Tuning condenser, padders, trimmers, coils and band-switch may all be part of a tuned circuit. 4—Check for an open in the cathode circuit. 5—Check the resistance of the oscillator grid resistor (R_1 in Fig. 1). 6—Replace the oscillator grid-leak condenser (C_1 in Fig. 1) with an equivalent unit. 7—Substitute a new plate by-pass condenser, if any is used.

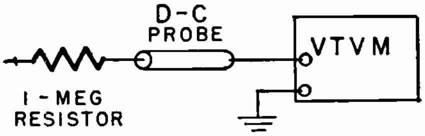
When only a few stations at the high end of the band are received, the oscillator may only be partially operative. The serviceman should, in such a case, check for inadequate plate and filament voltages; excessive cathode voltage (if the oscillator is cathode-biased); reduced capacitance in the grid-leak condenser; reduced value of grid-leak resistor; bad tube; defective oscillator coil.

Tube Variations

The question is sometimes raised, why do oscillators work for a while in certain receivers, then go dead? An allied query is, why will a new tube oscillate in one circuit, while it won't in another, similar or identical to the first? Basically, the same answer may be given to both questions. Let's develop this answer a bit.

When the transfer of energy in an oscillator is not adequate to sustain stable oscillation, the oscillator is apt to function until a sudden decrease in the line voltage reduces feedback below the critical level, causing oscillation to cease. The trouble is not, in such a case, due to the decrease in line voltage; it is caused by the inadequate transfer of energy in the oscillator. A sudden increase in the line voltage may cause the oscillator to start functioning once more, puzzling some servicemen no end. Possible sources of the trouble are the same as those cited for a partially-operative oscillator. The grid-leak voltage, incidentally, will be below normal when the condition just described exists.

Fig. 3—Inserting a 1-meg isolating resistor in series with VTVM "hot" lead.



Now, the replacement of the original oscillator tube with another one may remedy the condition, causing the serviceman to regard the job as finished. This may not, however, be the case.

Oscillator tubes vary in their transconductance. If a tube with an average or lower than average transconductance is used in the case we have been discussing, the unstable oscillations are apt to continue. (It should be noted that the same tube may perform perfectly well in an identical circuit where no decrease in the oscillator's transfer of energy has occurred.) If, on the other hand, a tube with a higher than average transconductance is substituted, the efficiency of the oscillator may be boosted far enough beyond the critical point to result in fairly stable operation—for a while. When the initially high transconductance of the tube decreases somewhat after several months of use, however, the original instability of the oscillator is apt to reappear.

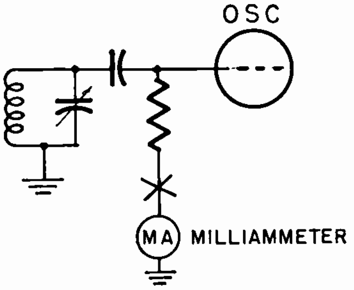


Fig. 4—Measuring grid voltage of oscillator with milliammeter. The circuit is opened at the ground side of the resistor (X), and the meter inserted as shown.

Oscillator drift—the last symptom on our agenda—is frequently due to a defective oscillator coil. Moisture absorbed by the coil when its moisture-proofing covering has broken down causes a varying leakage between turns, or a corrosion of some turn section, producing a drift. If replacing the oscillator tube does not eliminate the drift, a new coil should be substituted. When no exact replacement is available, the old coil may be dried out in an oven. It can then be covered with wax melted from a condenser, and rewired into the set, where it will often (not always) perform satisfactorily.

Servicing Vertical Sweep

Use of Scope and Calibrator Speed Troubleshooting.

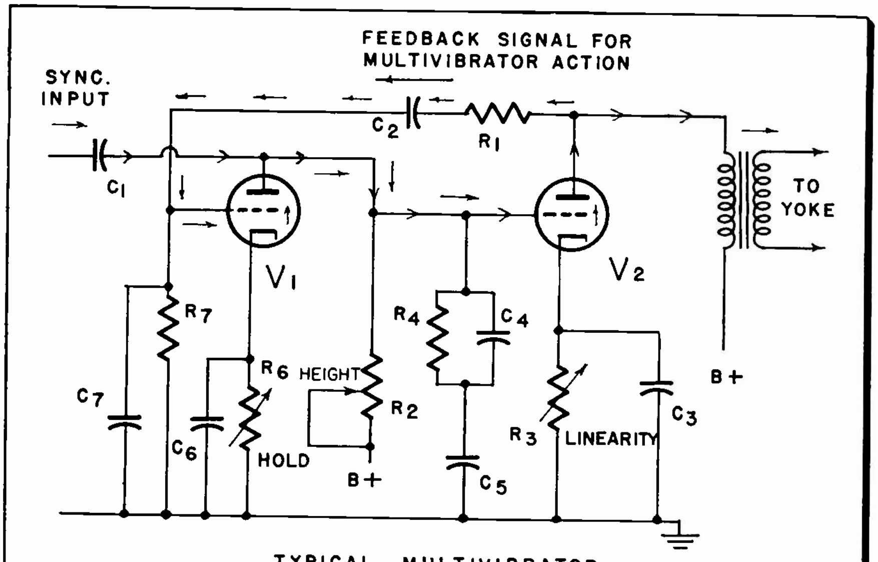
• The vertical section has been selected because although it is somewhat simpler than the horizontal section, in each case the methods for troubleshooting are closely parallel. There have been two main trends in the design of the vertical oscillators employed in modern receivers. The first to be widely used was the blocking oscillator type, which employed a transformer for the dual function of getting feedback from the output of the oscillator back to the input (to sustain oscillations) and for injecting the sync signal into the grid and mixing it with the feedback signal. The other commonly used method is the familiar multivibrator circuit, in which the feedback is from a second tube or tube section back to the first section through an R-C network. This type is coming into much wider acceptance as sets become simpler and smaller. The circuit of Fig. 1 is that of the GE 12T3, very slightly simplified, and is typical of present practice. A quick review of its operation is in order.

Integrating Network

After the composite sync pulses are amplified, they must be separated —the vertical pulse, being 60 cps is a low audio frequency, and can be separated from the relatively high frequency of the horizontal pulses by using a filter with a fairly long time constant. This long time constant merely smooths out the fast pulses (horizontal—15,750 cps) and does not greatly change the slow, or low frequency, vertical pulses. This filter network is called the integrating network, and its configuration is quite standard in most sets. It is shown in figure 2A. The values may change from set to set, but they are always similar in size. From the integrating network the snyc pulses are fed to the vertical oscillator. (Also called the vertical multivibrator, blocking and discharge tube, etc.) The pulses are used to trigger, or set off the vertical oscillations. They maintain the vertical sweep in exact *sync*ronism with the vertical sweep at the transmitter.

After being shaped by the integrating network, the vertical sync pulse is passed to V2, the vertical deflection output tube, where it is amplified. Part of this amplified pulse is now sent back to the grid of the first generator tube, V1 through R1 and C1. The values of these two parts are chosen so as to rule out amplification by V1 of any little bit of the horizontal pulse that may be left in the composite sync signal even after it leaves the integrating network. V1 amplifies the vertical pulse fed to it from V2, and from VI plate it goes, along with the incoming sync pulse from C_1 on back over to the grid of V2. Thus a continuous oscillation is maintained, with the sync pulses coming in from the sync amplifying section through the integrating network to keep the multivibrator working at the right speed. The vertical hold R_6 is set so that V1-V2 would be a little bit slower than 60 cps if the sync pulse didn't come in, so that the sync pulse may furnish the actual triggering of the sweep.

Now that the grid of V2 is working properly the plate circuit, consisting of the plate of V2, the primary of T2, the vertical output transformer, and the B supply, is receiving its pulses of current at a rate of 60 cps., and the transformer T2 supplies these pulses of power to the vertical deflection yoke as the vertical sweep.



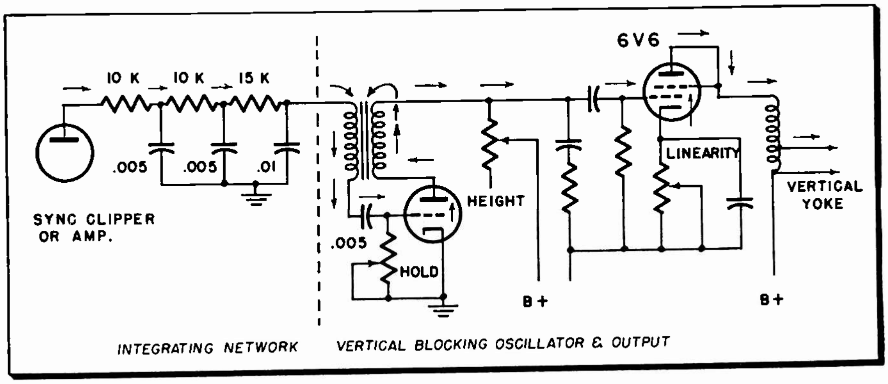
TYPICAL MULTIVIBRATOR

Signal Trace With Scope

Many technicians prefer to use a scope for signal tracing in vertical or horizontal circuits, and we incline to that view too. If the signal gets lost even though most voltage readings are right it's easy and fast to touch the scope lead progressively to the integrating network, oscillator grid, plate, output grid, and finally plate, and then to the secondary of the vertical output transformer. Remember here that you've got plenty of B plus to worry about, so use the rule of one hand behind you, or one hand in your pocket, while chasing the scope input lead through the set. This signal tracing with an oscilloscope will be found to be easier than the method of using a VTVM once you are accustomed to knowing what to look for at the usual check points because if a VTVM were used first, and failed to reveal the defect by improper electrode voltages, you would still have to use the scope. This way, the first step is eliminated. In connection with 'scope signal tracing it is wise to make full use of manufacturers or other service literature. These usually show photographs or simple outline drawings of the wave shapes to be expected in normal operation at each check point. Notice one thing in looking for these wave shapes; they may be drawn as they really are—not as they'll show up on a 'scope which has a fairly limited high frequency response. With a little practice you'll have no trouble in knowing what differences to expect in the published wave shapes and what you get on your scope. (All radio servicemen who use a 20,000 ohm per volt meter are easily able to mentally compensate for the difference between what their meter reads and what it really means in circuits of high or relatively high impedance.)

Circuits in TV Sets

Present Day Circuits Are Getting Simpler



A voltage calibrator is standard equipment in the best shops, being hooked right onto the scope input at all times so that input voltages can be instantly measured and compared with the values given in the service notes. The calibrator has a switch which, in the "Off" position allows connection directly to the scope, as though the voltage calibrator were not there. It also functions as a variable control of the input voltage to the scope. In this way it provides a method of finding out quickly where the vertical signal is being lost or attenuated. There are several excellent voltage calibrators now on the market. This tool has long been used as an aid in the laboratory, where the scope also was employed for years before it found such widespread use in TV servicing. Now top technicians are finding that leaving the voltage calibrator permanently attached to the input of the scope saves motion and time.

Common Troubles

Troubles in the vertical section of the set are among the most straightforward to handle. As with all types of TV failures, they will, a great deal of the time, be nothing but tube failure. So naturally we will pull and try new tubes first in the oscillator, then in the vertical output socket. If the set has a vertical buffer, or a vertical discharge tube, these are tried also. There is one vertical trouble which cannot be cured by working in the oscillator or output stages, however. It is called the keystoning effect. When the *raster* has a trapezoidal shape, when one side is longer up and down than the other, it is caused by trouble in the vertical deflection coil. The most usual cure for this is to replace the deflection yoke.

More common troubles are caused by failures or changes in the circuit components. The commonest trouble is the one which causes the customer to say, "I get only a thin white line." This is well known and indicates, of course, a complete lack of vertical deflection. After trying tubes, which we will from here on assume are the first thing attempted in all normal repair procedures, we check for B voltage on the plates. If that is found to be present, we go next to the cathodes, and if we get 2 to 13 volts there we're usually safe in assuming that the tube is drawing current. In some circuits, especially the oscillators, it is okay to have 100 to 150 volts positive on the cathode. Just jump over to the grid to be sure it has a comparable voltage, ten or so volts lower than the cathode. If you have this grid bias developed, the oscillator is almost always working, and the trouble lies beyond it. If no oscillations are present, then the ohmmeter is the tool for finding out why. At this point, the service notes are the best reference, and sometimes it's a little tricky to find a leaky condenser or an open in an oscillator circuit, so read that meter carefully, and use the right scale.

Less common than the "thin white line", but not unusual, is the folded-up, or "curtain-raising" effect. In this the vertical height is insufficient, and the bottom edge of the picture is bent back up over itself. This is due to a defect in the input of the oscillator, and in the circuit of fig. 1 would be caused either by a leaky condenser, C7, or a change in the resistance of R7, or R6. A shorted condenser C6 might produce a similar result, due to shifting the operation of the tube onto the wrong part of the amplification curve.

Improper Height

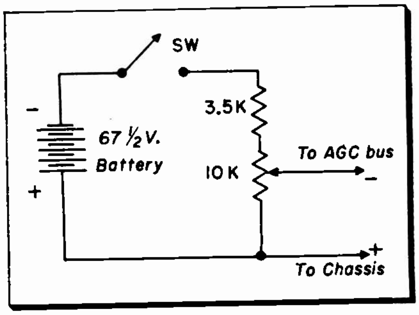
Inadequate picture height could be caused by a number of changes in the circuit constants. A frequent cause of this is a rise in the value of the plate charging resistance. Another cause would be shorted turns in the sweep output transformer or a cathode condenser C3 being too small, or becoming open. These would produce poor linearity, and possibly inadequate height also, depending on the exact circuit values involved. Almost any improper potential on the elements of the output tube might result in insufficient height, and certainly low emission of the tube would be a fault to watch out for. This would ordinarily have been taken care of, had good troubleshooting procedures been followed, as the first step in the initial examination of the set in the customer's home.

Inadequate height *combined with* a complete absence of vertical synchronization usually indicates a short in the cathode circuit of the sweep generator tube. In this circuit, a short in either the hold control or the condenser parallel with it would be the guilty components. Finally there is a whole raft of faults tied up with too much height, poor vertical linearity and the inability to control either properly. In this case the use of the voltage calibrator to check on the size of the input signal, and comparison of this with the value given in the service data would reveal the defect at once. It is a smart idea to have good equipment in the service department, in this case, scope and voltage calibrator. But the only thing that will service sets well is the right use of the tools.

SHOP HINT

TV Bias Source

A convenient method of obtaining a fixed bias voltage for use in align-



(*Continued on page* 48)

How New Automatic Focus

One Design Replaces Both Electrostatic-Focus and Magnetic-Focus Types.

By Charles Graham, Technical Editor

Procedure For Installing Automatic-focus Tubes

1. Remove focus coil from neck assembly.
2. Install centering device only when no variable DC centering is available through the yoke.
3. Plug new type CRT in and start operation.
4. Change ion trap if necessary. Correct type stated by tube mfr., and depends on amount of second anode voltage. Trap is adjusted for max brightness only.

• After changes in the design of cathode-ray picture tubes which have involved TV sets (and consequently servicemen) with *five* different beam focus-and-deflection systems, a means has at last been devised which provides a simpler way of focusing the electron beam than have any of the previous five. In addition, there are a number of advantages attendant upon this design which will further simplify the task of the technician who finds himself confronted with the job of replacing a weak or burned-out picture tube, or converting a small screen set to a larger size.

History of Developments

When non-mechanical TV was in its infancy there were two electron guns used. One was in CRT's like the present 5 and 7 inch oscilloscope tubes, and both beam deflection and beam focus were accomplished electrostatically. The other was a combination of magnetic deflection and electrostatic focus. This design was used in tubes as large as the 12 inch size. Unfortunately, when the circuit constants, line voltage, etc., varied, often the degree of focus did also.

The difficulty of manufacturing these guns resulted in higher priced tubes, and with the advent of tubes with wide deflection angles, the guns were unable to produce pictures of sufficient quality.

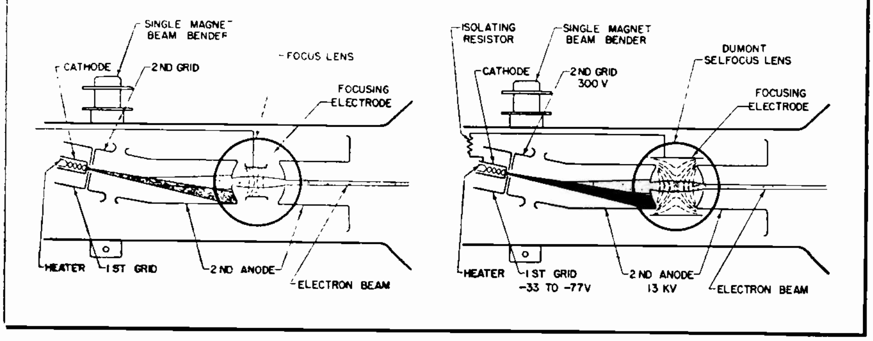
Meanwhile set designers switched over to the system of magnetic deflection and magnetic focus which is now familiar, and which is still the most widely employed system. When shortages were threatened last year, and it became clear that sooner or later set designs would have to be pared of excess metals, tube engineers went to work to try eliminating focus coil and focus magnet. Improvements in quality control of electron-gun production, and advances in research allowed them to come up with a system of electromagnetic deflection and electrostatic focus which was better than that obtainable before magnetic focus had become universal. Too, this time they were able to apply electrostatic focus to tubes of even a 20-inch diagonal (a size which was regarded so huge two years before that the tube had to be *specially* ordered, and it sold in the trade for over $200!).

A large number of these tubes, called electrostatically-focused, or simply "electrostatics", are today being used in TV sets. But although the use of electrostatics does save copper and cobalt (in focus coils and permanent magnets), it requires a focus voltage rectifier tube, a potentiometer, and at least three other small parts.

Low-voltage Focus

A partial solution to *this* problem (the requirement for the parts which make up the focus anode supply) was found soon after when some companies started engineering and producing *low-voltage* electrostatics. These picture tubes required, instead of one-quarter the second anode voltage, or about 2500-3000 V., only a few hundred volts. This eliminated need for the focus rectifier tube and some other parts, but it still called for a focus potentiometer across the B+ supply.

Fig. 1. On the left is shown a diagram of the electron gun for the older type of electrostatic focus. At the right may be seen the new automatic-focus electron gun.



Now on the market, both for replacement tubes and as initial equipment in new TV receivers, are automatic-focus tubes. This means that whereas in all previous models there has been some sort of adjustment (either a manual one, as with permanent-magnet focus devices, or an electrical control to vary the focus current or potential) now the serviceman will be required to make no manual adjustment of beam focus at all.

Zero Voltage Focus

In sets which use electrostatically focused tubes the new type tube can be substituted directly. No changes are necessary. Of course the focus control ceases to have any function.

As will be observed in the accompanying drawing, the electron gun of the new picture tube is similar in construction to the previous electrostatic type. The main difference is in the shape and placement of the focus anode. This electrode, together with the other grids and the second anode, forms an *electrostatic lens.* The purpose of the lens is to keep the electron beam sharp, of constant size, and as nearly circular in shape as is possible, throughout its trip down and across the face of the tube.

The resistor shown in the circuit between the focus anode and the cathode provides isolation for the focus anode for two reasons: 1. It reduces the input capacity of the tube in the case of cathode video drive. 2. Some manufacturers use little filtering of the second anode supply. Thus anode supply pulses might be coupled to the tube through the interelectrode capacity of the focus electrode were it not for the isolating resistor.

It was found that by increasing the

Picture Tube Operates

Requires Neither Focusing Coil Nor Electrode Supply

diameter of the focus electrode and having it overlap rather than fit between the two adjacent elements, it was possible to make many of the gun dimensions less critical. It also allowed more substantial physical mounting for this electrode, as can be seen in the photograph of the electron gun, fig. 2.

In sets which have electromagnetically-focused tubes as original equipment, the focus coil can simply be dismounted from the neck assembly and taped down on the side of the chassis out of the way. Or the focus coil may be removed completely and resistor of the proper size installed to take the place of the focus coil. (In the case of permanent focus magnets, naturally there is no need to keep the magnet once the new tube is installed.)

Focus Regulation

When the focus potential is a sizable percentage of the second anode voltage, as in the case of electrostatic-focused tubes, variations in the focus potential, or in the second anode voltage can cause a change in the degree of focus attained unless these voltages vary in direct proportion. This is one problem partially eliminated in the development of the low-voltage electrostatistics. By reducing the percentage of the second anode voltage which the focus potential represented, better regulation of the beam focus in relation to potential variations was accomplished. But it was still only a relative degree of regulation.*

In developing this newest electron gun, for automatic-focus tubes, DuMont engineers found that they had achieved almost perfect regulation of beam focus. That is, through the design of the electrostatic lens system in the electron gun, they had made the degree of focus sharpness almost entirely independent of reasonable variations in the second anode voltage. (Naturally, lowering of anode voltage will still produce dimmer pictures.) In addition, variations in beam current which previously caused changes in the size of the spot and focus were lessened in the new gun.

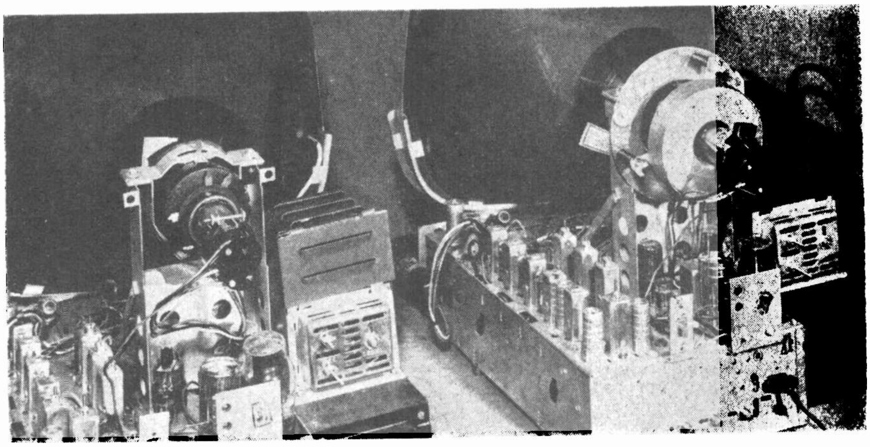
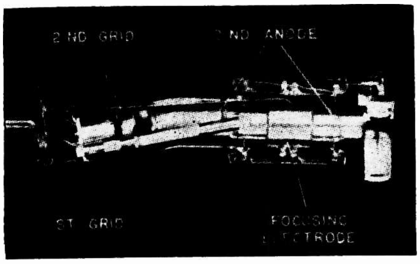


Fig. 3. DuMont set on left has simpler neck assembly due to new style picture tube. Small centering magnet at rear of yoke is required only on with sets having no DC centering.

Fig. 2. Photograph shows DuMont electron gun for no-focus voltage picture tube.



Finally, the new design increased the amount of the normal focus independence of line voltage variations and set warm-up. In the earlier sets, it was often necessary to readjust the focus control due to the warm-up.

Customer neglect of focus adjustment has much of the time resulted in an inferior picture which was not the fault of the set or installation. This tube removes the necessity for that adjustment.

Because of the shape of the new electrostatic lens system, there appears to be slightly better resolution of the beam at the edges of the pictures. This too has been a problem with some other tubes.

Conversion Steps

In converting sets the advantage of using this type of tube may be easily seen. In conversions *previously* it was necessary to go through three separate steps:

1. *Cabinet work.*
2. *Deflection circuit changes* —
   (a) usually changing horizontal output stage for more sweep and higher second supply.
   (b) changing yoke from 50 to 70 degrees.
3. *Focus changes* due to higher anode voltage, (and sometimes due to the requirements of the tube itself.)
   (a) More focus current was usually required.
   (b) Frequently a different focus coil was required.
   (c) The range of the focus control often had to be changed.

In converting to larger tube sizes with the automatic-focus type the third set of conversion requirements is eliminated. As a sales point, too, the customer can be honestly assured that this tube is the "latest" engineering development in cathode-ray tubes.

Cuts Inventory

The advantage of using this type of picture tube for all replacements is obvious when one considers that instead of having to keep on hand a 17-inch electrostatic-focus tube and a 17-inch magnetic focus tube, the serviceman or dealer can take care of either type with only one 17-inch replacement. The same applies to the 20-inch replacement stock problem. In this way the inventory of replacement picture tubes for smaller shops may safely be halved.

The cost of the automatic focus tubes is at present set the same as the price of the equal size rectangular tubes of other focus systems. DuMont is producing the 21KP4A, the 17KP4 and the 20JP4. Thomas Electronics is producing some of these tubes, and GE has announced the 17RP4. At presstime other manufacturers had indicated that they would soon produce these tubes, but could not yet make official announcements.

---

* A high degree of regulation, or *good* regulation is attained when the ratio of variation in the output or product is small compared to changes in the supply or the size of the load. Thus a power supply would be described as having *poor* regulation if doubling its load from normal cut the voltage supplied in half.

Printed Circuits Widely

New Units Gain Acceptance Because of Saving of Labor and Space

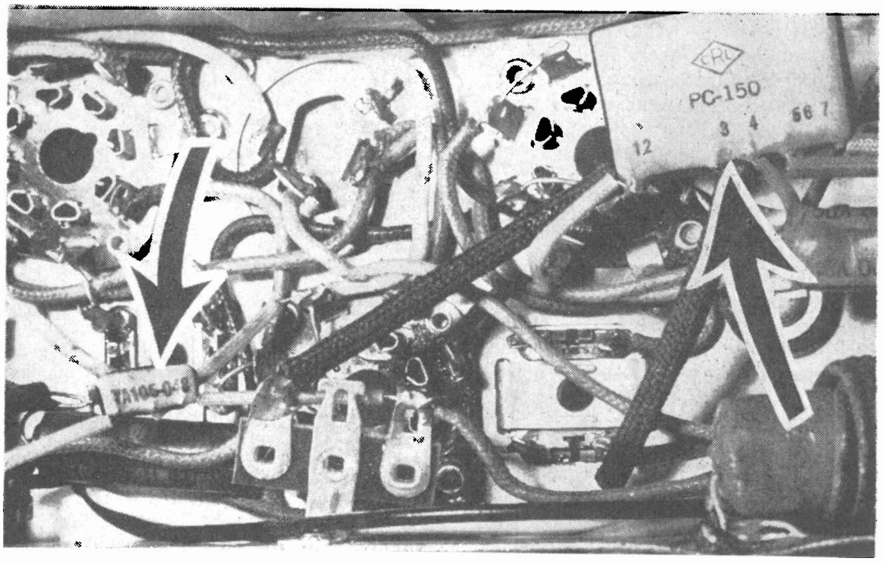


Fig. 1. Olympic AC-DC radio set shown above employs a printed circuit triode coupling plate (upper right). The smaller printed circuit plate directly above is a diode load network. At right here is reproduced part of schematic from Sentinel service notes showing triode coupling plate.

• When Grandad made his first superregenerative receiver from plans in the daily paper, he was told to use a lead pencil mark between "A" and "B", to make a resistor.

This *simple* resistor was one of the first clues to present-day printed-circuit techniques, and as a starter it lay almost absolutely still for about twenty years. Present-day printed-circuits have several advantages, yet the keynote to them all is *simplicity.* The pencil mark represents about the simplest component we could hope for, and our modern printed circuits aren't that simple. But they *are* made by mass-production methods, which is something Grandad wasn't able to accomplish. Today there are over 15 million printed circuit components in civilian sets. (Figures on military sets are still secret, but it is known that previous to civilian use the military necessity for compact parts and assemblies required large quantities of such components.)

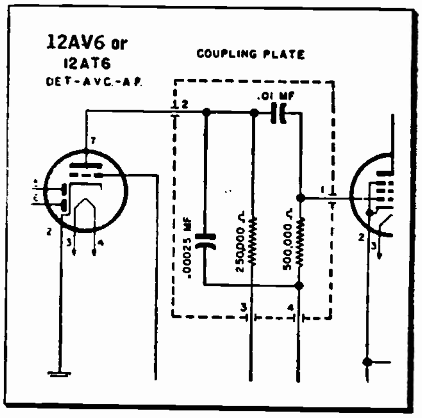
Because they are showing up increasingly in television receivers and other common electronic devices, a brief discussion of the construction, applications, and advantages of printed circuits is in order.

Just as miniature tubes were developed during the last war, and have now come into general use, so it is likely that a great many other miniaturizations, including printed circuits, will soon be used in everyday sets even more than they are now, due to defense research.

When "printed circuits" are mentioned, many technicians tend to think of the stamped metal antennas which have been widely employed in AC-DC sets. Or they recall the turret tuner which has its coils photo-etched in thin copper. But the type of printed circuit most widely employed today is neither of these. Printed circuits as they are used at present in TV and radio receivers are flat rectangular plates, generally between ¾" and 1½" long, about an inch or less high, and ⅛" thick. They are ceramic plates onto which have been bonded metallic paints and compounds to form resistances and small condensers in circuits where these parts are commonly used in the various sets with the same values frequently chosen. The vertical integrator plate, for example (See Fig. 2) is a combination of several condensers and several resistors in a circuit which is pretty standardized throughout the industry. Since the same circuit values can be used for this circuit (the vertical integrating network) in most TV sets, the circuit lends itself admirably to the use of a printed circuit plate. Another place where standardization of circuitry has progressed in the industry to a comparable point is in the coupling network between the output of the det-AVC-first audio stage and the power amplifier stage of small radios. Consequently, a large number of sets now employ printed circuit plates in this part of their circuit.

These components are most widely used in TV sets. Most hearing aids use printed circuits, naturally, because of the extreme small size available, and many portable and AC-DC table sets are including them.

Both resistors and condensers may be made by the printed circuit technique, and when both are fabricated in various combinations, they save not only space, but a great deal of time and work in the manufacture of the circuits they are part of. This is because they incorporate so many circuit components into one piece, with the common, internal connections already made, and hidden in the body of the piece.



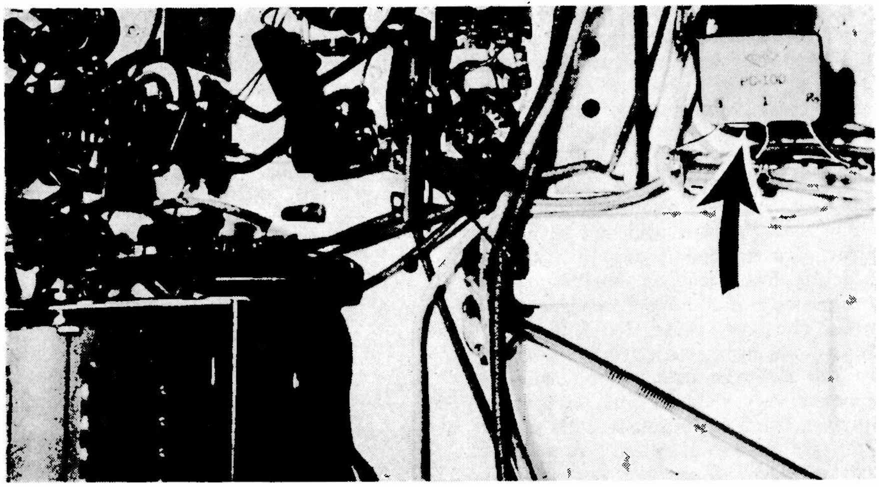
See Fig. 1 for diagrams which compare the number of soldering and wiring connections normally required in the construction of a plate coupling network with the number needed with the use of a printed circuit unit. In this audio coupling network between a pentode voltage amplifier and the next stage, it will be seen that ordinarily *eleven* various points and *five* components would have to be connected together with *eight* or more soldering and twisting operations. With the printed circuit unit this is reduced to five solderng points, and *one* component.

The best example of this sort of saving is in the vertical integrator plate, however. Here *eight* parts become *one,* and *twelve* or more interconnections become *three* soldering operations!

There are over twenty different printed circuit components being produced today. Of these, the vertical integrator network (See drawing, Fig. 2 is the most widely employed, being used at present in over three million TV receivers. Running a close second is the printed circuit coupling plate*, with over 2,750,000 in portable and table radios. There are also over a million small filter networks* already sold to set manufacturers and almost as many printed output

Used in Current Sets

in the Manufacture and Servicing of Radio TV and Equipment



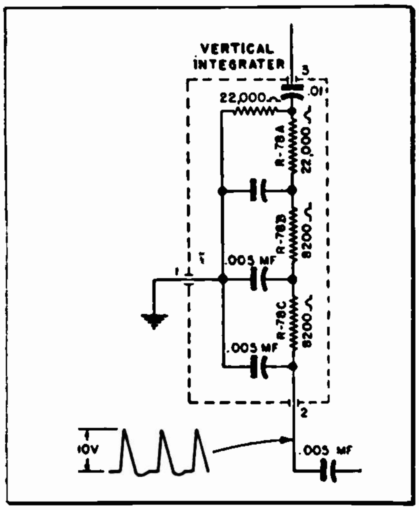


Fig. 2. Photograph above shows most common printed circuit component in use today. It is the vertical integrator plate. Typical manufacturer's service diagram is partially reproduced at left to show (inside dotted lines) the eight parts which are included in single printed circuit part. Only *three* external soldering connections are made.

stages*. Fifty or so manufacturers have already used these components in one or more sets each.

From the above statistics, it may be seen that printed circuits, though comparatively new, are rapidly spreading in use. With the speed-up of research and development which the present defense electronics program is bringing about we may reasonably look forward in the near future to even more widespread employment of these parts.

The National Bureau of Standards has already conducted a large program aimed at producing improvements in printed circuit design for manufacturers to the armed forces. This program has developed some important advances in design which are undoubtedly incorporated in military equipment, but are still for security reasons not in civilian use. When they can be released for public benefit, they will change the appearance of home receivers even more than did the advances made during the last war.

In another type of printed circuit metallic paints are sprayed or painted onto insulating surfaces to form the "wire" connections between various circuit components. A different composition of paint is subsequently applied at the proper points to serve as resistor. This sort of printed circuit is used in many hearing aids.

Naturally, such resistors cannot be employed in parts of the circuit which carry substantial current. They are, generally speaking, good in circuits where up to 1 or 2 watt values are usually specified, but not in power output or supply sections.

If part of a printed circuit were to be replaced, as for example, in a hearing aid, the simplest solution would be replacement of the entire printed unit. Failing that, in many cases, it is possible to replace just the faulty condenser or resistor. If this cannot be done, as for example, when several resistors and condensers are contained physically in the same unit, then it is necessary to replace the entire printed unit.

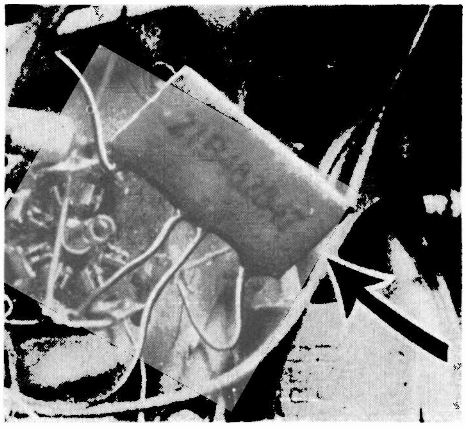
In some cases it is possible to replace just the faulty part, with paint from kits which are now commercially available for the purpose. If a resistor were to be replaced, metallic paint of the appropriate kind would be applied, the resulting resistance measured with a voltohmeter, and more paint added, or some scraped away, until the proper resistance value was obtained.

Regular condensers (or even resistors) can be soldered into printed circuit, as parts replacements, if care is observed not to damage the insulating plates and other circuit parts. Solder which has some silver content is needed for this sort of soldering, however. One caution is in order. When a printed circuit plate is to be replaced in a receiver, often the numbers which identify the leads projecting from the plate are numbered in a different order from the lead numbers which are on the original part. In such cases, the new part should have its leads soldered in the same order, counting from left to right, into the circuit, without regard for the numbers shown. A physical comparison is used—not the numbers.

The advantages which the manufacturer obtains from the use of printed circuit components in his sets may be summarized as follows: (1) Several parts may be replaced by one part. (2) Installation time on the production line is saved through fewer connections to be wired and soldered. (3) Since there are fewer connections to be made by the assemblers, there is lower probability of mistakes. (4) Space is saved — allowing smaller chassis, or more room for other, outsized, or non-standard parts.

These advantages are leading more and more manufacturers to the use of printed circuit components, so we will continue to find more and more of them in the radio and TV sets of today and tomorrow.

Motorola table set shown below uses connections with a P.C. plate.



***Centralab's trademarked names for these components are *Couplate, Filpec,* and *Audet,* respectively.**

Servicing and Maintaining

Key to Profitable Phonograph Maintenance Is

• The step-child of many service departments is the handling of record-changer repairs, and allied phonograph problems. Yet today there is renewed interest in phonograph records as an entertainment medium, due at least in part to the advent of microgroove. With the upsurge in sales of records has come a stepup in the number of phonograph service calls. In addition, the use of fine-groove records has made the listener more readily aware of minor flaws in the operation of the changing mechanism. This is because here the output of the needle is smaller in relation to machine-noise than it is in the case of regular groove records. A further complication is the introduction of better quality sound into present-day combinations, resulting also in "better" reproduction of rumble, scratch and distortion.

In the past, many shops have regarded changer service as such an unimportant part of the work that they have not even had a rack to mount the changer on when it came in. A recent informal survey by the writer found racks in less than one out of four radio repair departments. Yet all the shops stated that they did changer repairs and further, that such repairs were increasing in volume.

Most phonograph repair jobs start with an outside service call. It is important that the outside technician know his own limitations; that he be able to correctly and quickly recognize when a changer repair is not the kind to be done in the home. Many jobs that should have been done in the shop have become needlessly complicated by having been first attempted in the customer's house without proper equipment.

Take the case of Jim Doakes, serviceman. After putting a new needle in Mrs. Jones' changer (an old single-speed one which had a lot of cast white metal parts) he showed her how well the new needle sounded. Jim was about to leave when Mrs. Jones asked him if there was anything he could do about the fact that sometimes the arm did not drop just right. He figured it couldn't be very difficult, even though he was unfamiliar with the adjustments on this model changer. After looking in vain for a positioning adjustment he lifted up the changer and, seeing what he thought was a small nut on the arm spindle, tried to loosen it with a spintite. Of course it wasn't a nut, but just a piece of casting and it broke off, disabling the machine. Jim tried to fix it, but with no success. (It happened there was no such adjustment at all on this early-type machine.) Finally, he had to leave a very irate Mrs. Jones and promise to come back the next day with a new part. It took three weeks to get a replacement part for this old model changer, and even then the changer had to be picked up and brought into the shop for the replacement. The dealer lost a lot of good-will and money in this case because (a) the technician was so anxious to please that he attempted a job he was unfamiliar with, and (b) he attempted a job in the home which should have been done in the shop.

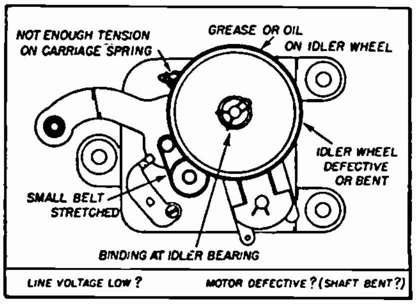
The outside man must be able to tell when the job cannot properly be accomplished in the home, and he must be sufficiently self-assured to tell the customer, firmly where necessary, that the job cannot be done correctly on the spot.

He must not use this means to cover up a lack of proper equipment being carried on the outside call. This equipment should be contained in a kit kept separately for just the times when needed and should include at least the following:

A stroboscopic disc, for use under an AC light source — for checking speed of turntable.

A phono test cartridge, with shielded lead 3 ft. to 4 ft. long and clips at its end. (Removable-needle type).

Carbon tet and/or alcohol, and cloth.



Above: Mechanism is part of V-M changer, used in many combinations today.

Pressure gauge for measuring weight of needle on groove.

Lubricating grease and *light machine oil.*

Small *kit* of *replacement needles,* both sapphire and metal.

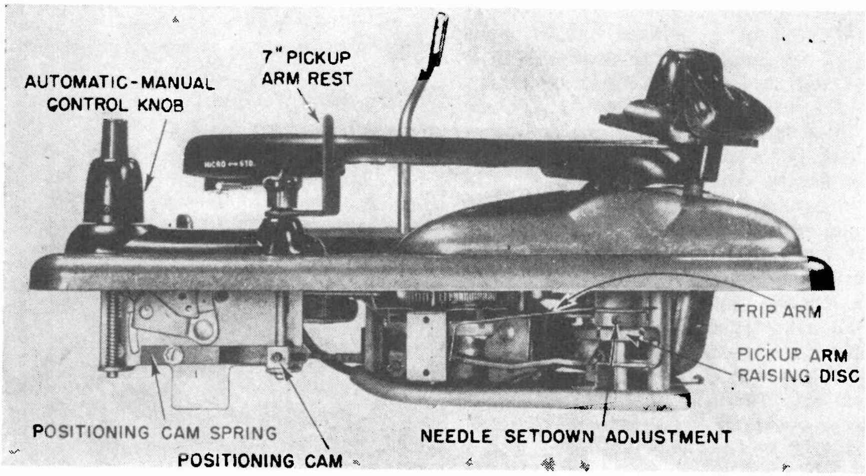
With the kit of phonograph adjustment equipment listed above, the serviceman should be able to correct most minor troubles and make most adjustments. It is assumed that in addition he will have the usual complete radioman's set of tools with him.

Repair jobs which cannot be handled outside will also require, beyond the things listed for the outside phono kit, *manufacturer's factory data, universal AC (fused) test leads* for checking motors, *rack* for mounting the changer and turning it upside down when necessary.

For testing the operation of mechanisms after they have been completely repaired and adjusted, a stack of records, both 10" and 12", some 12" 33 RPM, and a few 45 RPM discs should be kept in the service department.

There are also available *test records* which will rapidly *check* the *changing cycle* of record changers. These records have only about one groove per inch, so that they run in to the center in four or five revolutions.

Below, in a typical factory service photo is shown a side view of Webster-Chicago's model 106.



Phono Record Changers

Use of Proper Equipment, Including Manufacturers' Data

In shops where high-quality machines are sold or repaired, a *test record* for checking the *frequency response* of the entire system will prove helpful. These records are made by major record companies, and carry grooves modulated with frequencies from 50 cycles to 10,000 cycles, thus providing a check not only of the needle and cartridge, but of the amplifier and speaker also. In cases where rumble is the complaint, it is helpful to have an amplifier and speaker with very good bass response available for checking this point.

Do It in the Shop

Whenever the trouble is not merely an adjustment which could have been made with a screwdriver, or by replacing the cartridge or needle, the changer should be brought into the shop. The technician who attempts to repair Mrs. Jones' changer in her home beyond the aforementioned repairs is asking for trouble. Involved changer repairs cannot and should not be attempted without a proper rack and the benefit either of manufacturer's diagrams, or years of experience.

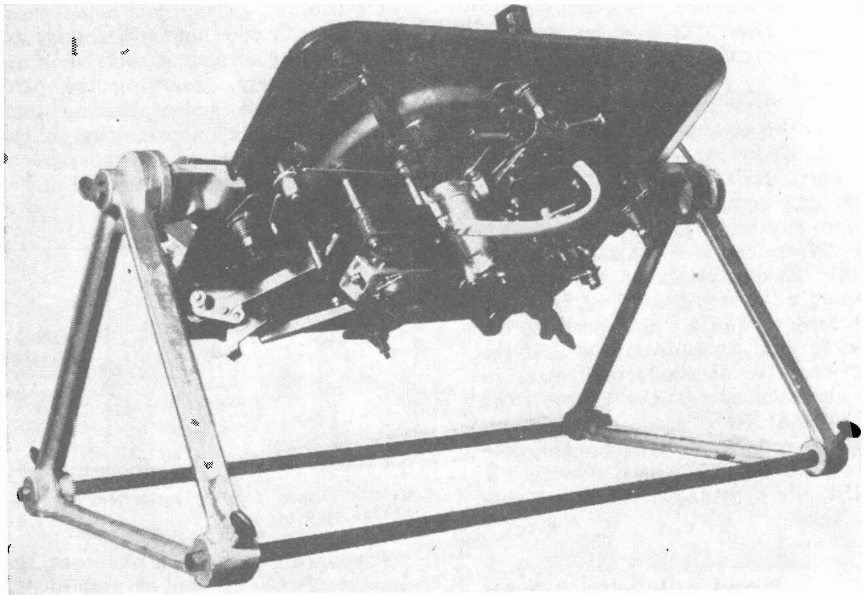
Caution! See that no one in your shop ever puts a changer, regardless of make, directly on the floor. It takes only a very slight bump to bend or break the parts of many changers. See that pieces of cardboard are available at all times where changers may be set down.

After the changer is in the shop, it should be set in the rack and, if in operating condition at all, started running. Put one or more records on it and observe its action and see what it fails to do.

If the complaint is "rumble", "squeaking", "thumping", etc., that is, if it is mechanical trouble, but not a failure, then the section of this article dealing with *Maintenance* should be referred to.

If the trouble is a failure to properly accomplish some part of its dropping, changing, or playing cycle, usually the manufacturer's service information will list the common failures and the points to check for eliminating them.

To check mechanical operations, move the turntable by hand on the rack. Move it in the reverse direction if it is jammed. But be careful. A light hand and several years of experience are helpful here. Be certain what you're doing, particularly if it involves *bending* or *twisting* any part of a mechanism. There are almost no repairs that call for this, so stay away from it unless the manufacturer's literature specifically recommends it.



Mounted on adjustable changer rack for easier, faster repair is a Garrard 3 speed changer.

Bridging the test cartridge across the leads of the old head will show at once whether the trouble is in the cartridge or in the set. Most crystals will read high resistance if weak, distorted or dead, and will therefore not materially affect the input impedance of the test head. (Normal resistance of crystal heads is about 2, 3, or up to 10 megs. Variable reluctance heads read much lower—200 to 500 ohms being typical.)

Bad tone which affects only the high notes will usually be caused by a worn or chipped needle, if the fault is present only on phono (not on radio). Particularly with microgroove records the problem of worn needles will be more prevalent than it was with 78s. This is true because (a) the wearing pressure is much greater on the tip of the needle than with 78, despite much lighter total weight, (b) "Permanent" needles are in much greater demand and wider usage than ever before. (c) Present day equipment is capable of much better fidelity and high frequency response, showing up needle wear much more readily than did earlier, poorer equipment.

If the distortion is severe, *and is accompanied by a loss in volume*, the crystal should be suspected. A quick easy check for crystal failure of this sort is to press the crystal lightly to one side of the groove. If this restores most of the proper tone, then one of the two elements of the crystal is dead. Replacement of the unit is the only remedy.

When the motor fails to turn and the servicer has determined that there is no simple failure of contact in one of the interconnecting cables or plugs between the main AC line and the motor, then it is reasonable to suspect the motor itself. Most phono motors for 110 V, 60 cycles, read about 10-20 ohms, a reading much lower than this or considerably higher will indicate shorted turns, or if high resistance, an open in the motor. It usually does not pay to rewind such motors, so a replacement motor must be installed.

More and more changers, particularly in the three-speed category, and in the expensive sets with extended frequency response, will give rumble troubles or speed variation troubles. There are three speed variation difficulties which can occur.

The most common, and easiest to recognize, is "wow." So-called, because of the sound of the word, it is caused by periodic changes in the speed at which the turntable goes around. These changes are very slow (from about ½ change per second on 33 RPM, at the slowest, to a few per second). They are usually due to defects or foreign material in turntable, turntable bearing, main idler, or some other fairly slow

(*Continued on page* 41)

Crystal Diodes Replace

Use of Germanium Units Found Increasing in 1951 Models; Simplification of

- First used in military electronic equipment during World War II, germanium crystal diodes have recently been proving their worth in consumer products, particularly television sets. They are now available for replacement purposes, as well as in original equipment.

Briefly, these units are basically the same as the crystals we knew in early crystal receivers: that is, they are rectifiers. It is mainly the characteristics and constructional features of the new crystals which make them different from early crystals. The latter usually used crystals of the mineral Galena; a "cats whisker" or fine wire was used to find a "hot spot" on the crystal; and the characteristic of the unit was that it conducted better in one direction than the other. The 1N23's that were used in radar employed crystals of silicon, and the units that are being used now in TV (1N34, etc.) utilize crystals of germanium.

Many Advantages Seen

One characteristic of the silicon and germanium crystal diodes is that it isn't necessary to search for a hot spot with the catswhisker, and therefore the latter can be permanently fixed. This means that the crystal diode can be sealed up in a cartridge, which greatly increased its utility. Other characteristics of these diodes are: Relatively flat response at Very High Frequencies over a relatively wide dynamic range of signal levels: low forward resistance, which contributes to good rectification efficiency at low signal levels; transit time, interelectrode capacitance and internal noise, which are limiting factors in the use of vacuum tubes at VHF and UHF, are relatively negligible in the germanium diodes; and finally, of course, when compared with a tube, the germanium diode with pigtails can be soldered in like a resistor—takes little space, needs no filament wiring or other voltages, and no tube socket.

Reverse Current Passed

On the negative side, it should be mentioned that germanium crystal diodes will not withstand as high inverse voltages nor as high ambient temperatures as will equivalent vacuum tubes, such as the 6AL5. Also, it is well to note that while the back resistance is much higher than the forward resistance (the ratio is about 100:1 for germaniums) it is nevertheless a finite resistance (roughly about 100,000 ohms), and current will flow in the inverse direction. A vacuum tube diode, on the other hand, would pass no current if its anode were made negative.

However,—and this should really have been listed under the advantages—the life of a germanium diode (estimated at 10,000 hours) greatly exceeds that of a vacuum tube when operated properly, observing the peak inverse voltage and operating temperature. Table 1 shows some of the pertinent features of the more popular types of germanium crystal diodes used in TV receivers.

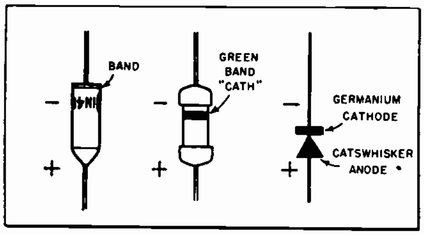


Fig. 3: Proper polarity indications for germanium diodes.

For circuit connection purposes, the characteristics of the crystal diodes are shown in figure 3. Considering the interior of the crystal, the catswhisker is comparable to the anode of a rectifier and the germanium crystal is the cathode. As would be expected, the plate is considered to be the positive end and the cathode the negative. As in a tube rectifier circuit, however, the output is taken from the cathode. This is shown in the simplified schematic of figure 4. On the Sylvania (1N34, 1N60) crystals, the cathode end is marked with a green band. On the General Electric (1N64, 1N65) crystals, the cathode end is the larger end (opposite to the tapered end). Earlier Sylvania diodes had a "plus" and "minus" sign instead of the green band. The newer GE crystals also have a band on the cathode end. The "minus" end corresponds to the cathode end and should be placed in the circuit so that it faces the "plus DC" output end of the circuit. This is important due to the relatively low inverse rating of the units and the fact that they *will* pass current in the wrong direction.

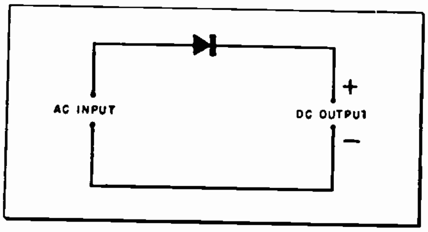


Fig. 4: Output taken from cathode (minus) end of diode.

Several Uses In TV Sets

A typical video detector circuit using a germanium crystal diode is

Table I

	1N34	1N60	1N64	1N65	6AL5
Peak Inverse Volts	75	70	20	85	330
Inverse current @ —50V	.8ma	(not known)		.2ma	0

Ambient Temp. Range*—50° to + 75°C for all types —
* Fahrenheit = 9/5 (C + 32)

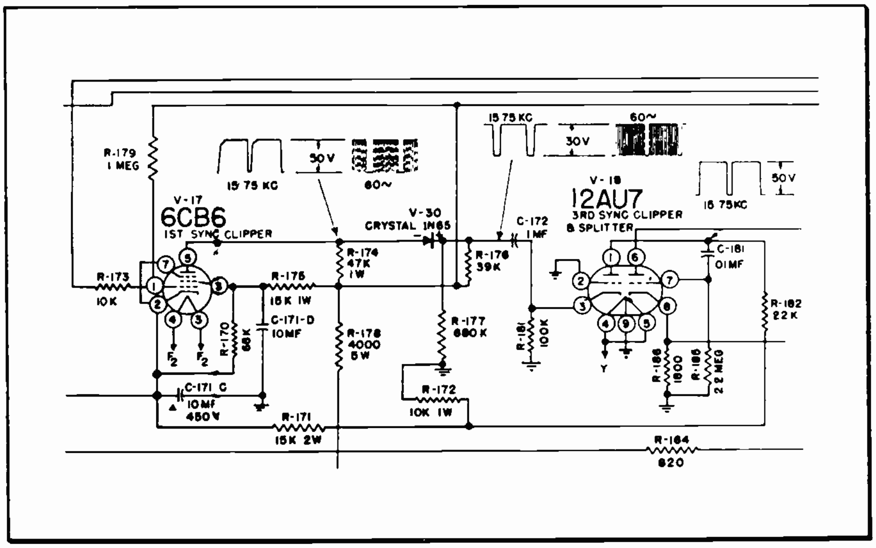
Table II

Current TV models using a germanium crystal diode as video detector

Make	Models	Crystal
Andrea	Normandy	1N34
Arvin	2121TM, 2123TM, 2120CM, 2126CM, 2124CCM, 3080T, 2161TM, 2160CM, 2164CM, 2162CCM	1N64
Brunswick	616, 6161, 1116	1N34
Emerson	673, 660, 665, 664	1N60
Freed	54, 55, 56, 68, 101, 103, 104	1N64
GE	All current models	1N64
Hallicrafters	805, 806, 809, 810	1N60
Hoffman	All current models	1N60
I.T.I.	248, 348	1N34
Magnavox	Cosmopolitan	1N36
	French Provincial	1N60
Majestic	All current models	1N64
Mercury	6111, 6114, 9114	1N34
North Amer. Philips	1200, 588	1N34
Pilot	127, 163, 166	1N60
Setchell-Carlson	150, 1500, 1500LP	1N34
SMA Co.	111, 114, 117	1N34
Stewart-Warner	9200A	1N64
Tele-Tone	All except Imperial models	1N64
Trad	All current models	1N34
Zenith	All current models	1N64

Tubes in New TV Sets

Manufacture and Servicing as Well as Improved Performance Noted



Many Other Types and Uses for Germaniums

The use of germanium crystal diodes in a wide variety of equipment [close to 3 million will have been sold by the end of this year] can be considered still in its infancy; and the use of these units in home TV receivers, covered in this article, represents but one of the many growing markets for them. At present approximately half a dozen out of more than 35 available types are being employed in TV sets. In addition to this use, many are finding their way into radios (particularly FM), test and measuring equipment, commercial and government communications equipment, research equipment, etc., and new uses for them are being uncovered daily.

shown in figure 5. The receiver is General Electric 16T3, 16T4, 16C113 and 16C116.

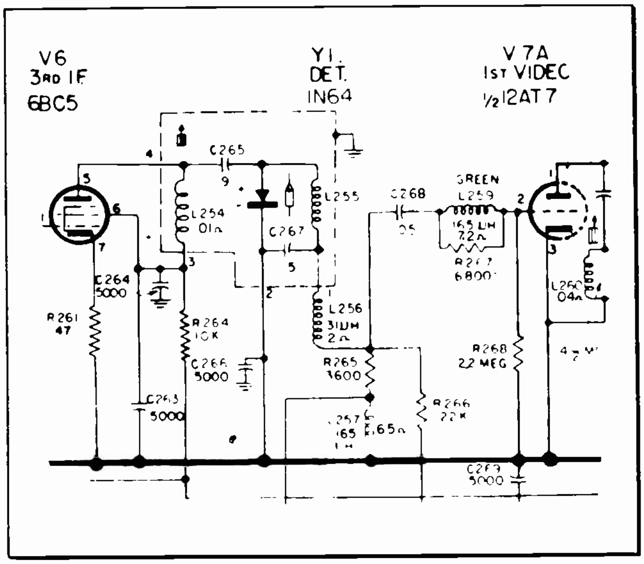
Still another application of the germanium crystal is shown in figure 6, in which is shown a portion of the schematic of the Stromberg Carlson 119 series receivers (Empire, Georgian, 18th Century and Chinese Classic). V-30, a 1N65, is used as the 2nd Sync Clipper. This operates in conjunction with V-17 (1st Sync Clipper) and V-18 (3rd Sync Clipper and Splitter) to remove large noise pulses, to maintain the proper blanking level and to separate the sync signals from the video.

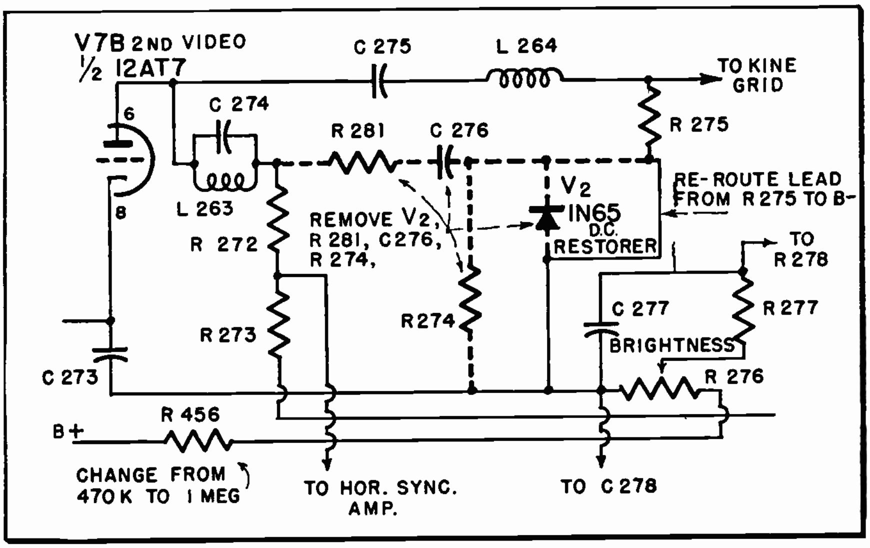
Used For DC Restorer

Germanium diodes may also be used for DC restorers. Substitution of a 1N65 for a 6AL5 DC restorer in the GE models 12T3 and 12T4 is shown in figure 7. Many of the late model sets, however, eliminate the necessity for DC reinsertion by using direct coupling from the video amplifier to the grid of the kinescope.

Of course, the uses for germanium diodes outlined in this article are but a few of the many possible uses. The purpose of this article was only to show uses found in current model TV receivers. Nor are all the many types of diodes which are available described here, but only those found in the aforementioned TV sets. There are some types which accommodate back voltages up to 200 volts, and there are some (silicon types) which are useful at frequencies up to 10,000 MC.

Fig. 5 (at right) a portion of the schematic for GE TV sets 16T3, 16T4, 16C113 and 16C-116. The symbol beside the diode is the physical appearance of the unit as shown in fig. 3. Fig. 6 (Above) Stromberg Carlson 119 series. Due to an error in the original diagram, the symbol for V-30, the 1N65, should be reversed from that shown, so that the bar designation (the cathode) connects to the plate circuit of V-17. Receivers are wired correctly in this respect. Fig. 7 (below) GE model 12T3, showing how a crystal diode can be substituted for V2, 6AL5, the DC restorer.





Suppressing Local Oscillator Radiation in TV Receivers

Proper shielding, grounding, and orientation of oscillator components; adequate rejection in coupling and power supply networks reduces chassis radiation

By JOHN P. VAN DUYNE
Allen B. DuMont Labs., Inc.
2 Main Ave., Passaic, N. J.

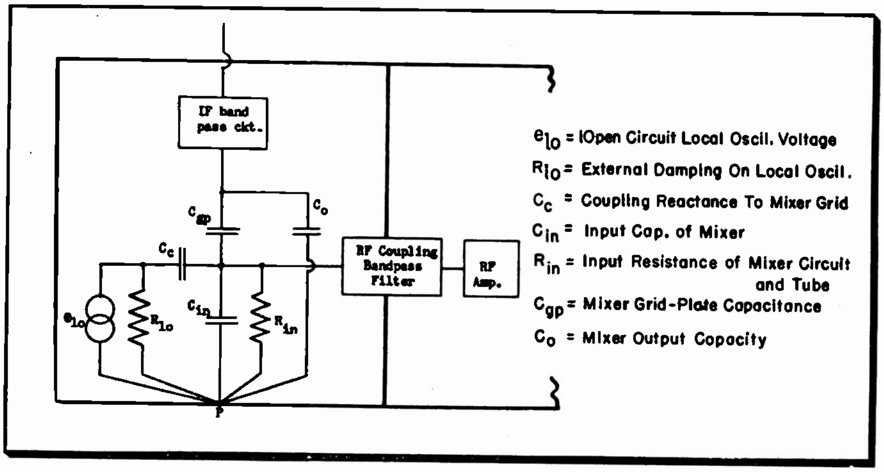


Fig. 1: Shielded local oscillator equivalent circuit. R-F and i-f bandpass filters introduce sufficient attenuation at local oscillator frequencies to make their ground returns relatively unimportant

DURING the last three years, there has been a mounting engineering interest in the suppression of incidental radiation capable of interfering with radio broadcasting and communication services. This interest stems from an engineering conference on oscillator radiation held by the FCC on Nov. 1, 1949. At this conference, attention was drawn by the FCC to the fact that during the period July 1, 1948 to June 30, 1949, 1,730 complaints of interference to broadcasting services were received.[1]

These complaints covered many sources of interference, but the most rapidly growing source was that from the LO (local oscillator) of TV receivers. As a result of this conference, the RTMA Committee on radio interference was reorganized and an active compaign was begun on Jan. 11, 1950 in New York City. At this time, the R15 Committee of RTMA was made aware of the magnitude of the problem and the FCC desire for an early solution.

TABLE I: Radiation Data on Typical Untreated TV Receiver

Channel	Antenna Plus Chassis Field Strength µV/Meter*	Chassis Alone Field Strength µV/Meter*
4	52	34
5	100	90
6	168	113
7	426	464
8	450	487
9	474	592
10	900	972
11	1478	1296
12	1850	1924
13	1865	1872

* Measurements by standard IRE method. RTMA limits: low VHF band 50 µv/meter; high VHF band 150 µv/meter;

The work of this committee and that of the IRE Committee on radio receiver test methods culminated in the adoption of two standards: (1) a standard of allowable radiation limits for TV and FM receivers by the RTMA, and (2) a standard on "Method of Measurement of Spurious Radiation of Frequency Modulation and Television Receivers" (50 IRE17 PSI) by the IRE Committee. Once the TV design engineer had a specific limit and method of measuring performance against that limit, it was possible for him to design economical TV receivers to meet the specified radiation limits with a reasonable safety factor.

There are several sources of incidental radiation in a TV receiver. These are, in order of importance: high frequency LO, horizontal deflection system and associated high voltage generator, video i-f amplifier, sound i-f amplifier, and video amplifier. By far the most serious of these has been the high frequency LO radiation. The remainder of this article will deal with methods and techniques useful in the design of a TV receiver and particularly its r-f tuner to meet the new RTMA radiation limits on LO radiation. Space does not permit a discussion of the other forms of interference here.

The LO radiation problem may again be subdivided into "antenna radiation" and "chassis and/or power line" radiation. The power line radiation situation will be considered a special case of so-called chassis radiation. This is due to the fact that excitation of the power line is a result of the same leakage of LO energy from the r-f tuner that excites the whole chassis. By antenna radiation, we mean that component of radiated interference which may be eliminated by the removal of the transmission line from the receiver and the substitution of a matched dummy load resistor. The remaining interfering radiation will be referred to as "chassis radiation."

Experience to date has indicated that when starting with an existing receiver design, by far the most serious component of radiation is the chassis radiation. See Table 1 for supporting data. This is not necessarily true once the design has been altered to minimize chassis radiation. The progress of a radiation reduction investigation is analogous to the problem of the archeologist. When he uncovers one layer of interesting relics, has carefully dusted off and restored each one of his important finds, and is about to sit back and enjoy a well earned rest, he discovers that there is yet another layer peering through the dust to mock him. This results in a certain amount of jockeying to and fro from chassis to antenna radiation and the need for constant field testing of "improvements."

Unfortunately, as the engineer begins to peruse the available literature on these problems of radiation reduction, he soon finds that the bulk of the literature is concerned with antenna radiation and mentions little of the problems of chassis radiation. This is natural in view of the fact that prior to the wide sale of TV and FM receivers which operate in the VHF region, most receivers, both home and communication, operated in a frequency range such that the chassis was very small compared to a half wavelength, hence minimizing the importance of chassis radiation.

However, in the case of TV receivers, the chassis usually is big enough to approach half-wave resonance in the 174 to 216 MC TV band and therefore is an efficient radiator. Once this situation is realized, the next step is usually to pull the dust cover off the nearest available VHF standard signal generator and view, in awe, the elegant shielding employed by the manufacturer of the instrument. It would be nice if it were practical for the TV designer to construct the LO of his TV receiver in a manner similar to the signal generator. Unfortunately, however, the economics of the situation prevent this course of action. The buying public would not be favorably impressed with an increase in list price consistent with employment of signal generator techniques.

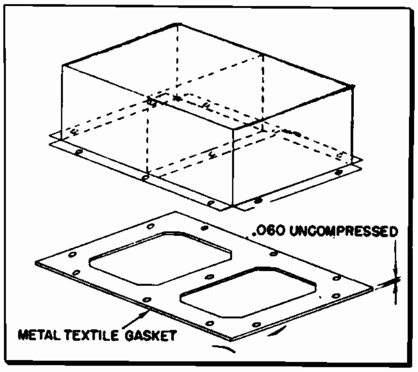
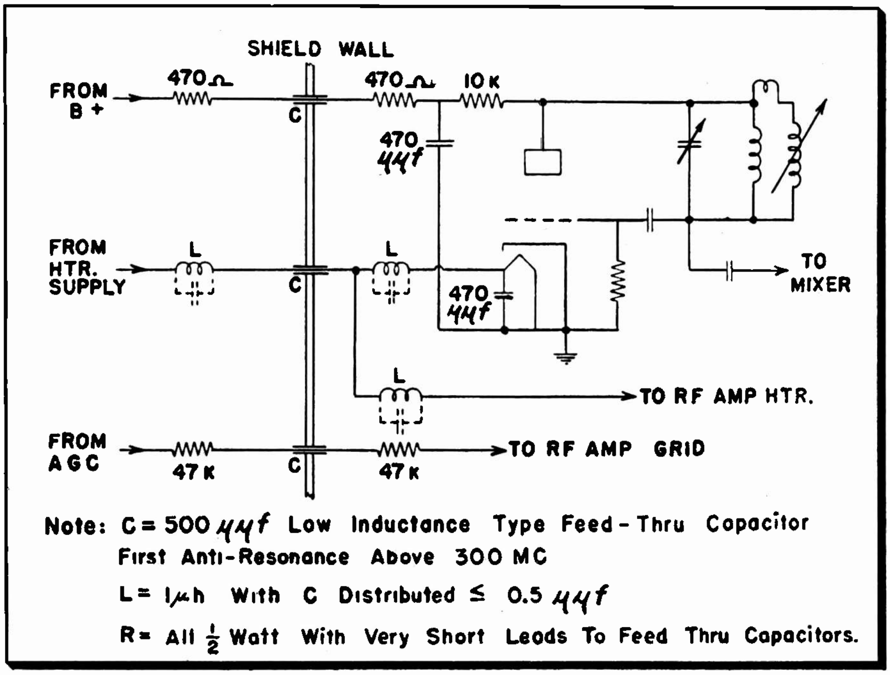


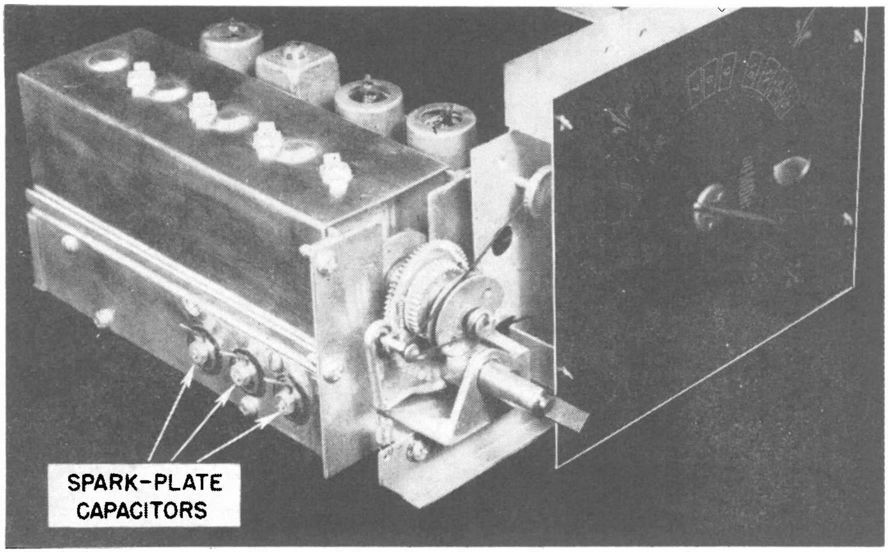
Fig. 2: Typical shield construction



Note: C = 500 μμf Low Inductance Type Feed-Thru Capacitor
First Anti-Resonance Above 300 MC
L = 1 μh With C Distributed ≤ 0.5 μμf
R = All $\frac{1}{2}$ Watt With Very Short Leads To Feed Thru Capacitors.

Fig. 3: Filter arrangement designed to prevent spurious resonances within oscillator tuning range

Fig. 4: Spark-plate capacitors employed to filter B+; heater and AGC leads passing through shield wall



Signal Generator Techniques

However, it is possible for the TV design engineer to profit immensely by careful consideration of the techniques employed by the signal generator manufacturer. The principles exemplified by this construction may be applied in a much less expensive manner to a TV tuner. Following a further discussion of the basic problem, we shall discuss such techniques as applied to a TV receiver.

Reference to an elementary text on radiation discloses that we get a radiation component whenever an electromagnetic field is accelerated in a medium of finite velocity of propagation. If this radiated energy is not totally reflected, the original electromagnetic field experiences an energy loss. It is the job of the designer to provide either for the reflection or the absorption of this energy which would normally be lost to the LO and gained by the receiver in the next apartment.

In order to prevent the radiation of energy by the receiver chassis, it is obvious that we must prevent the excitation of that chassis by the LO energy or totally reflect the energy radiated by the chassis. Since it is wasteful of material to attempt to confine a field within such a large volume, the most economical approach is that of preventing the excitation of the chassis.

Thus we may state that the basic problem confronting us as design

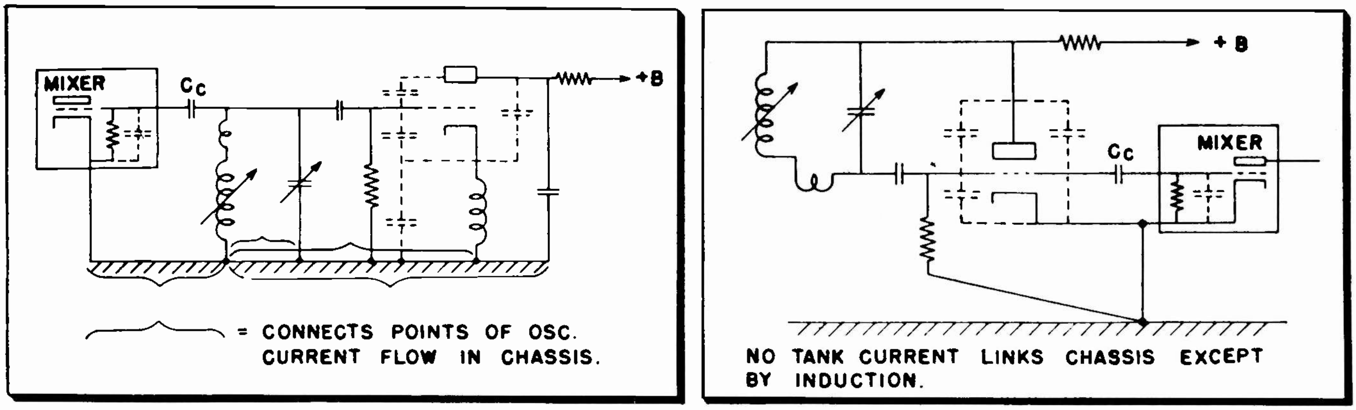


Fig. 5A: (L) Poor oscillator design causes conduction currents in chassis. Fig. 5B: (R) Good oscillator design reduces chassis currents

engineers is to confine the electromagnetic fields due to the LO to the immediate vicinity of the LO. The degree of this confinement is, of course, established by the limits that one is trying to reach. The RTMA limits on radiation have been established with the intent of protecting the maximum amount of service area without imposing an impossible economic burden on the buying public.

There are several characteristics peculiar to TV receivers which aid the program of LO radiation reduction. These are:

a. The oscillator is operated on the high frequency side of the desired signal, separated from the sound carrier by 21 or 41 MC in modern receivers. This separation permits relatively simple and inexpensive selective circuits greatly to attenuate the oscillator signal before it reaches the r-f amplifier plate circuit.
b. The i-f is removed by at least one octave from the oscillator frequency. This permits i-f band pass circuits of proper design to discriminate greatly against the oscillator signal.
c. A higher degree of r-f circuit shielding is required by a TV receiver for many reasons other than oscillator radiation suppression. It only remains to extend this shielding to include the problem of oscillator radiation.

There are also some problems in the TV receiver which complicate a low radiation design. These are:

a. The need for a high degree of economy and reproducibility in the design.
b. The circuits located within the shielded compartments must be available for quick servicing.
c. The chassis used in TV receivers are large enough to be rather efficient radiators, especially in the 174 to 216 MC band.
d. The use of metal cabinets may, under some circumstances, in-

TABLE II: Local Oscillator Radiation Reduction Results

	Antenna Plus Chassis Radiation		Chassis Radiation Alone	
TV Channel	Before µV/Meter*	After µV/Meter*	Before µV/Meter*	After µV/Meter*
4	52	11	34	Less than five
5	100	11	90	Less than five
6	168	7.3	113	Less than five
7	426	32	464	7.2
8	450	28	487	7.0
9	474	52	592	7.2
10	900	27	972	5.6
11	1478	26	1296	6.2
12	1850	41	1924	13.
13	1865	29	1872	25.

* IRE Standard Method

RTMA Limits: low UHF Band 50 uv/meter; high VHF Band 150 uv/meter

Fig. 7: Grid-separation amplifier and equivalent circuit. Plate current in input has LO component

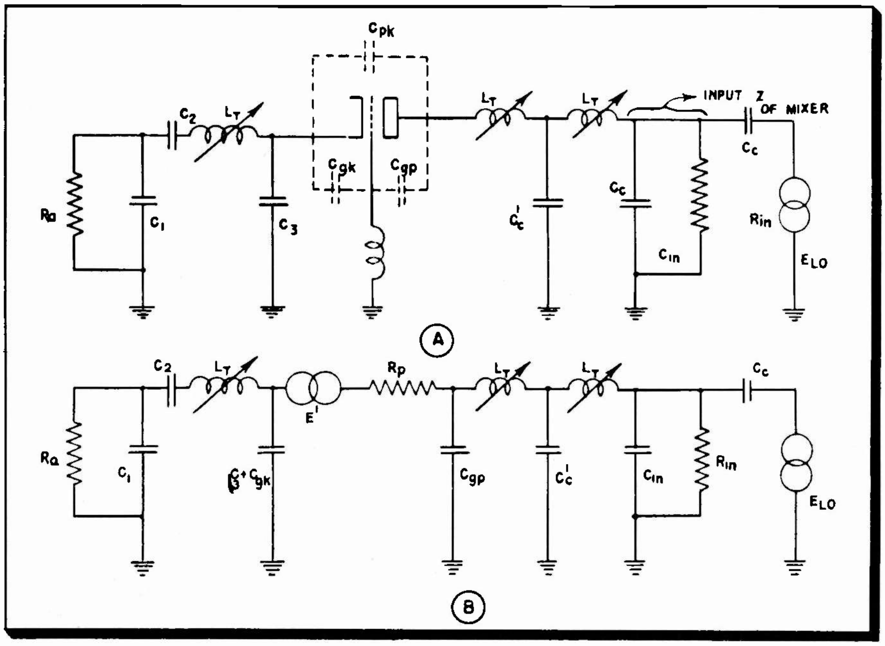
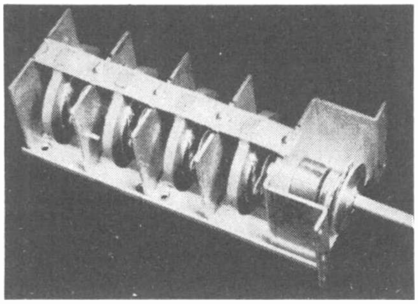


Fig. 6: Continuous inductance tuning unit



crease the effective radiation surface.

e. Our present defense effort has made it necessary for the designer of civilian goods to conserve metals, especially the highly conductive ones which are most desirable for r-f shielding.

With the preceding facts in mind, the designer then proceeds to the task of selecting circuits and physical layouts to accomplish his ends. The following rather obvious points are listed so that it may be easier to follow a detailed discussion of each point. These are the general means for restricting the electromagnetic fields of the oscillator to the vicinity of the LO. Fig. 1 illustrates some of the following points:

a. The oscillator and mixer circuits must be enclosed in a conducting shield as completely as possible. Shield joints must be designed in accordance with the principle of minimum leakage consistent with ease of shield removal and economy of manufacture. The shield should be fastened to the next larger support member at points of as near equal potential as possible to minimize excitation of the larger surfaces.

b. All power supply leads entering the above mentioned compartment must be filtered for r-f.

c. The oscillator must be so designed that it produces a minimum of current in the surrounding metal. This may be accomplished by the following general methods:
   1. Single point grounding must be used for the entire oscillator circuit.
   2. The oscillator inductor must be oriented so that its field induces minimum currents in the surrounding metal.
   3. The oscillator inductor field may have to be restricted by such means as a complete coil shield or vestigial shielding such as a shorted turn surrounding that coil.

d. Since the mixer or frequency converter tube is driven by the LO, usually via control grid injection, it is necessary to design the band pass networks associated with the mixer tube for minimum transmission at oscillator frequencies.

The obvious, but uneconomical, way to design oscillator shielding is to enclose the oscillator by means of soldered, "water-tight" joints in the shielding and possibly the use of double shielding. This is obviously not a reasonable approach to high production. The approach should be that since the shield must be inexpensive and readily removable, extreme emphasis should be placed on minimizing the magnitude of currents induced in the shielding by the LO. It is of even greater importance to prevent the actual conduction of oscillator current by the chassis and/or shielding. Once the oscillator currents in the shielding have been reduced to a sufficiently low value, the need for precious metals in the shield compartments and the need for multitudinous grounding fingers or mounting screws is minimized. Almost any crude metal box of rather low conductivity material, such as thinly plated steel, will adequately confine the electrostatic field, providing that there are no holes or slots in the shield across which a potential difference can exist. This can usually be accomplished, for the electrostatic field, by proper orientation of holes and slots. However, such is not the case for the electromagnetic field.

The presence of any holes will permit magnetic lines of force to "bulge" through the opening, thus permitting the excitation of currents upon the exterior of the compartment shield. These currents then excite the main chassis which is a fairly efficient radiator and the damage is done. From that point on, additional filtering of leads or careful placing of components within the oscillator compartment will be to no avail. Thus holes must be avoided at all costs. This means that supply leads must leave the compartment in a manner that prevents magnetic lines of force from accompanying the wire. The means of accomplishing this with a filter will be discussed later. One hole that is very difficult to avoid is that for the tuning shaft. It is possible to minimize leakage of this nature by use of either an insulated shaft in an elongated bushing (waveguide below cut-off attenuator) or by careful grounding of a metallic shaft together with care in minimizing excitation of the shaft by oscillator currents inside of the compartment. This latter approach is by far the most practical in a TV tuner. It admittedly does not allow the same degree of attenuation as the former method, but experience has proven it to be adequate.

Shield joints, whether fastened by screws or by spring pressure, should have as large an overlap as possible to minimize leakage which is inevitable in joints between metals that are not of the highest possible conductivity and so carefully formed that they provide an almost water-tight joint. This is the big point of departure from signal generator technique. Grounding fingers are no doubt desirable, but they are equally uneconomical. Since shields in TV receivers must be made of sheet metal in great quantity and at low cost, the tolerances that may be specified are of necessity loose. This means that the designer must be very cautious, especially when designing the joints, to provide for the necessary allowances and at the same time accomplish contact over as great an area as possible. A practical means for accomplishing this (see Fig. 2) lies in the use of a gasket of a metal textile to provide good contact between mating non-planar surfaces.

A further point of departure from signal generator technique lies in the choice of metals for the shield. Brass, copper, and silver are entirely uneconomical as base metals and are further unthinkable in view of the requirements of the defense program. On the other hand, high conductivity metals are desirable, in that smaller thicknesses are necessary for a given attenuation of a confined field and that good joints are more readily obtained. A metal thickness of about 10 times the "skin depth" is necessary to produce an attenuation of approximately 86 db in the field intensity. This would require approximately .003" of copper if the minimum frequency were 80 MC. This amount can be most economically produced by "overlay" techniques.

If overlays of copper are used, the shields should be formed with the copper on the inside. However, experience has shown that cold rolled steel will provide adequate attenuation in thicknesses of 0.030" or more, if the joints are plated with at least 0.0005" of copper. This latter shield, together with the previously discussed care in minimizing current density in the shielding will produce very satisfactory results. The main enemy of the effectiveness of such shielding is corrosion and care must be taken in handling and fabrication to minimize such tendencies.

The necessity for adequate low-pass filtering in the power supply leads is obvious. In the case of high voltage and automatic gain control lines, it is possible to use series resistor, shunt capacity filters. It is important that the capacitors not experience any anti-resonant effects within the tuning range of the oscillator. The use of series resistors of a few few hundred ohms on both the input and output of this filter usually prevents resonance in the supply leads exterior to the tuner. It is usually necessary to use LC filters in the filament leads to avoid excessive voltage drop. These filters must be designed to prevent any spurious resonances in the tuning range of the oscillator. See Fig. 3 for typical filters. Several types of capacitors are suitable for use in these filters. One type has been used by automobile radio manufacturers for years under the name of "spark-plate" capacitors. Fig. 4 illustrates such capacitors. This technique is applicable to the TV receiver if material of adequate insulation resistance and dielectric strength is used. Another alternative is the use of either disk or cylinder "feed-through" types of ceramic capacitors.

As mentioned earlier, it is of extreme importance to minimize the flow of oscillator tank currents in the chassis or shields of the tuner. Fig. 5 A shows an oscillator circuit that is very bad from the standpoint of causing conduction currents to flow in the chassis. A change to the circuit of Fig. 5 B will eliminate this portion of the difficulty.

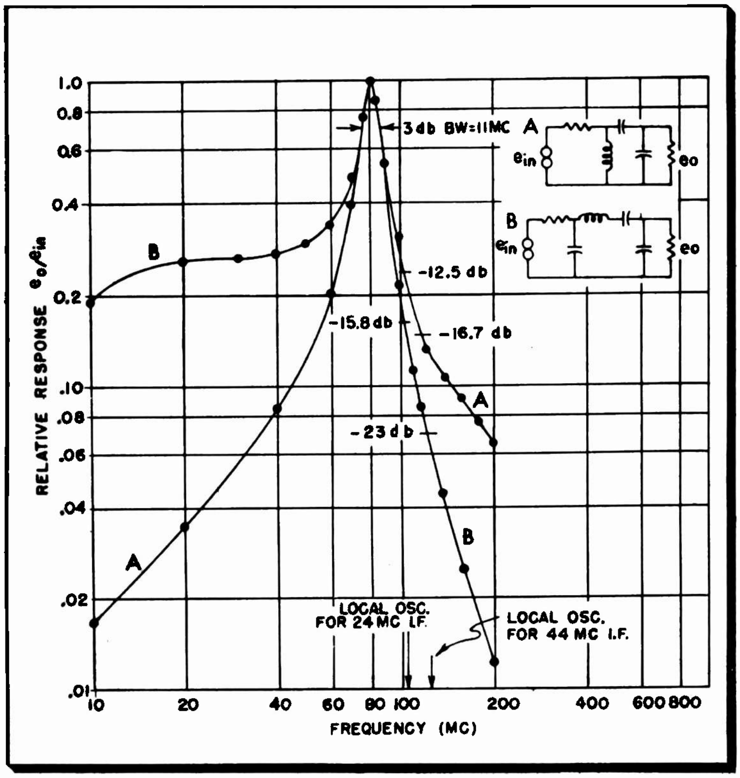
It still remains to locate the oscillator inductor so that its magnetic field links the chassis and shielding as little as possible. In switch, turret, or permeability tuners, this can be readily accomplished by winding a coil with a fairly high ratio of length to diameter and the use of high permeability core material to confine the magnetic field, plus spacing from the chassis of at least two coil diameters. Most pure permeability tuners suffer from a rapid increase in chassis radiation at the high end of the tuning range. This may be due to the increased extent of the field about the oscillator coil when the core is fully removed from the coil. Hence, the use of combined permeability and eddy current shielding tuning is indicated. Naturally, the conducting shield used for eddy current shielding inductance variation must surround the inductor if the desired confinement of the field is to be obtained.

Some forms of continuous inductance tuning devices such as shown in Fig. 6, have a naturally extensive magnetic field. Since, for minimum back-lash, the oscillator inductor must be close to the tuning shaft, it is somewhat difficult to minimize excitation of the shaft. A partial solution to this problem has been the use of a conducting ring in close proximity to the oscillator coil field. This ring can also be used as an aid to tracking, due to its effect on the oscillator coil inductance. In the high VHF band, the effect of the ring is small, due to its looser coupling to the coil. Fortunately the shaft excitation has been found to be a major problem only in the 90 to 110 MC region where the shielding of the oscillator coil field is relatively great.

The problem of confining the local oscillator energy which is conducted from the shielded compartment by the antenna and i-f output leads is one which is readily susceptible to quantitative analysis. However, the results of analyses of this nature must be viewed in the light of maximum attainable figures, rather than the preordained result of following the schematic diagram that was analysed. This departure of results from theory can be minimized if care is taken in the analysis to include all the significant reactances.

The usual approach is to assume that for reverse transmission, the r-f amplifier tube is a passive network composed of the interelectrode capacitances and lead inductances. This is not true in general, but only in special cases. Pentode r-f amplifiers, in which there are a minimum of common impedances in the cathode circuit may be successfully analysed as a passive network. Cathode separation triode r-f amplifiers usually follow this theory also. However, the grid-plate capacity is not the only coupling. Above 200 MC, the cathode lead inductance may allow direct conduction of oscillator energy into the grid circuit, even with C_{pg} perfectly neutralized.

A somewhat different condition occurs with grid-separation amplifiers, since the plate current flows in the input (cathode) circuit. The



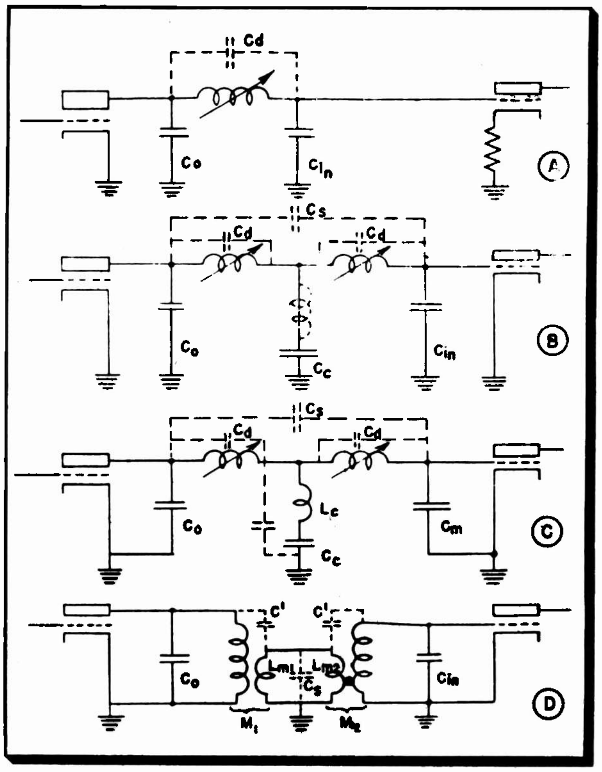


Fig. 8: (L) Comparison of selectivity of anti-resonant circuit (A) with high selectivity input (B) shows greater attenuation of (B) prevents reverse transmission of LO frequencies through r-f stage. Fig. 9: Mixer bandpass couplings circuits, stray reactances dotted.

plate current contains a component of LO signal due to the rather low plate resistance of the triode and this component appears across the transformed antenna impedance. See Fig. 7 for details. Normally, one would expect that the antenna component of LO signal due to a finite R_p would only be noticeable at frequencies so low that X_{cpk} was equal to or greater than R_p. This occurs about 65 Mc for $C_{pk} = 0.5$ uuf. Sometimes an effect occurs above 200 Mc in which the antenna radiation varies with g_m of the tube. This has been traced to regeneration in the r-f amplifier at frequencies well above the signal frequency, but close to the oscillator frequency. This is usually a result of the grid circuit impedance increasing due to L_g (see Fig. 7). Thus, it is essential to provide a high degree of antenna circuit selectivity at oscillator frequency if a grid-separation triode r-f amplifier is used. Such an input circuit and its selectivity curve compared with a simple anti-resonant circuit of equal Q is shown in Fig. 8. The popular "cascode" or driven grounded grid circuit affords another means of achieving high antenna circuit selectivity together with the passive isolation of the cathode separation input triode.

Much more can be said about proper design of interstage coupling circuits for LO energy suppression, but would be a subject for a paper in itself. Suffice it to say that r-f band-pass circuits between the antenna and mixer grid should have maximum "above band" rejection and those between mixer plate and r-f grid should have similar abilities. It is also essential that the stray reactances associated with practical components should be negligible all through the LO tuning range. Fig. 9 illustrates some of these circuits, together with the dangerous stray reactances which are shown dotted.

The degree of improvement in radiation reduction that can be achieved by the application of some of the previously discussed techniques is shown in Table II. The figures shown are results of measurement of a complete receiver, before and after radiation proofing, by the IRE field method.

In conclusion, a note of caution should be sounded. It is possible, by careful circuit "tailoring" to produce substantial reductions in antenna radiation due to presence of two or more sources of leakage of opposite phase. In TV receivers, the frequency range is so great that such "bucking" is unlikely to hold over the frequency range and is certain to be impossible of attainment in mass production. It is necessary, if uniform results are to be achieved, studiously to avoid such cancellation phenomena. It is far more economical, in the long run, to put a few more cents into a good sheet metal design that is subject to simple inspection techniques, than to rely on "tricks" which will pile up rejects, or worse still, place radiating receivers in customers' hands.

Thanks are extended to Mr. E. G. Mannerberg without whose cooperation this paper could not have been completed.

1. K. A. Chittick, "Report of Engineering Conference on Oscillator Radiation of the F.C.C. on Nov. 1, 1949."

UHF ANTENNAS

(*Continued from page* 8)

b. **Utilize built-in or cabinet-top antennas—principally in strong signal areas.**
c. **Install a separate UHF antenna on the existing mast, feeding both UHF and VHF antennas into a common transmission line by using a special coupling network.**
d. **Make an entirely separate UHF installation if the location of the VHF antenna is not satisfactory, or move the existing VHF mast to a position suitable for both services.**

Record Changers

(*Continued from page* 33)

turning part.

The second common variation in the speed at which the turntable revolves is "flutter." This is a more rapid periodic change in the speed of rotation. It may be roughly said to go from about 15 times a second up to the point where it is no longer noticeable. Most people will react to flutter by saying, "the phonograph is going too slow", or "it sounds slow, or sick." This is, of course, partly true since variations of this sort will usually be accompanied by some slowing down. But the slowing down is not what they hear. Contrary to the opinion of most people, they cannot tell when a record is going very slightly slow or very slightly fast unless they are extremely familiar with the particular record. When they say it's going slow, the odds are ten to one it has flutter.

The third trouble is actual slowing down of the turntable. On governor-controlled phonographs, which are almost out of existence as new equipment, the cause is usually a lack of lubrication, or an accumulation of dirt and grease in the governor. In synchronous motors, which most phonographs today have, the trouble may be too heavy a pickup arm, a broken needle point, cold motor (grease thick—gets back to normal after warmup), dirt on any moving part, or lubricant dried up. The rubber idlers or belts should also be checked.

Maintenance on record changers consists of checking for proper operation, cleaning, and lubricating. The proper cleaning agents are carbon tetrachloride (alcohol is *usually* OK, but be careful of the material it is used on) and a cloth, with a small brush for getting into tight places. All surfaces such as the working surfaces of the motor pulleys, idler pulleys, idler wheels, inside turntable wheels, and friction surfaces in governors, should be carefully cleaned, allowed to dry, and then run for a while. At the same time, before test-running, the bearing surfaces (or inside), of these parts should be cleaned of oil and dirt, and then covered very lightly with a light grade of machine oil. (It cannot be said too often that much of the trouble in new or recently-repaired changers comes from over-generous lubrication. What may not seem like excess oil when the parts are at rest quickly gets distributed to other parts of the machine as soon as the changer starts operating.) Be careful not to lubricate brake surfaces or certain parts of governors. Manufacturers' literature always shows a pictorial diagram of the places for lubrication. In addition to these places, many changers require a couple of drops at each end of the motor every few months. In a large percentage of these motors, there are small pieces of felt near the bearing ends of the motor axle which are intended to hold the lubricating oil. (Do not saturate these — use just two drops in most cases.

Often a flat on the main idler wheel can be eliminated by taking the rubber wheel off and reversing it; that is, turning it inside out.

After the repair has been made, a stock of records should be placed on the changer and allowed to play through two or three times before the changer is marked "ready" and put aside for delivery.

New York TV Stations Utilize

ERP comparisons for transmitters at the same location but on different frequencies first time. FCC's permission to increase powers adds approximately 10,000 square miles

By *JOHN H. BATTISON*
Consulting Editor

LATE in 1949 when the announcement was made that WJZ-TV would share the top or the Empire State Building with WNBT, considerable interest in the project was engendered by the television engineering fraternity. Here was a challenge to the ingenuity and resourcefullness of engineers in applying previously known principles of diplexing to *four* carriers from adjacent radiators.

Later, in rapid succession it was announced that WCBS-TV, WABD, and WPIX would also erect antennas on the same tower and plans for a multiple unit transmitting antenna were drawn up. Then in July of this year it was announced that WATV would probably join the other five telecasters on the top of the highest building in the world. Final authority has been received from the FCC for modification of WATV's construction permit to make this change in location.

As a first step in the ending of the freeze, the FCC recently removed its restriction on the use of maximum power by the existing 107 TV stations. One result of removing the power limitations is that most existing stations can increase the output of their transmitters to the full rated output which is 5 kw for all except community stations.

The removal of the power limitation means that WNBT is now operating from the Empire State Building with 14.5 kw, WJZ-TV is using 17.0 kw from the same location and WPIX is radiating 21.7 also from the new antenna. WABD and WCBS-TV are radiating 14.25 kw and 20.1 kw respectively from their original installations, and WOR-TV is radiating 22 kw.

The factor of greatest interest to both engineers and telecasters in all these power increases is what happens to the service areas of stations when the power is raised. In all cases referred to above the *effective radiated power* (ERP) is used since this is a factor which influences coverage assuming height and frequency are similar. For the first time in television history it is possible to compare the effective coverage of television stations operating with similar high powers and from the same antenna height—within a few score feet, which is negligible at 1400 ft. above sea level.

So far in these tests it has not been possible to obtain comparative coverage maps due to the short time which has elapsed and the fact that there are various methods of expressing service area currently in use. For instance, NBC and CBS use the 0.1 MV/M contour as the limit of service while some other stations use the earlier 0.5 MV/M contour as the measure of service. The FCC has instituted a new grade of service area connotation by labelling the areas grade "A", and grade "B". Also at this time the three stations using the Empire State facilities have not completed full measurements. Probably it will not be until WCBS and WABD join the other stations that a really comprehensive and comparative survey will be made. After all, one field trip would suffice to measure all five, or six, transmitter strengths, and it would result in economy in manpower and effort.

As far as WNBT is concerned, an increase in service area of about 9 miles radius has been obtained with the increase of power to 14.5 kw ERP. This results in adding about 10,000 square miles to the total service area. The antenna was rephased slightly to increase the signal to the nearby areas, but this did not affect the service contour.

The major effect of these power increases has been to extend the service area in all directions and provide a usable signal in areas that before were considered "fringe." In addition, while improving the signal strength more or less uniformly, it has the advantage that at the points where previously there was interference between co-channel stations the signal strength at these points has increased so that even if the interference contour has not moved further away the signal strength, and hence the signal to noise ratio has improved.

Same Coverage Increase

In the case of WJZ-TV with a power increase to 17 kw the 0.5 MV/M contour has moved out to 57 miles and the 0.1 MV/M contour to approximately 75 miles. Probably all the stations on the new tower will experience about the same relative increase in signal strength coverage. In many cases the FCC authorization merely specified that power might be increased to the maximum 5 kw rated output of the transmitter, rather than a definite ERP.

It is quite possible that WNBT experienced the greatest improvement in signal with the power increase since it previously had a very low ERP due to its high antenna and consequent severe limitation to keep

ERP COMPARISON FOR TV STATIONS IN NEW YORK AREA

1. Station	2. Old Power Transmitter	ERP	3. Old Transmitter Locations Power under Order 5 Transmitter	ERP	4. Power under Order 5 Empire State Transmitter	ERP
WABD	4.0 KW-V 2.5 KW-A	14.25 KW-V 9.45 KW-A	same as 2 4 KW Transmitter		5 KW-V 2.5 KW-A	16.7 KW-V 8.4 KW-A
WCBS-TV	3.0 KW-V 2.5 KW-A	13.7 KW-V 10.2 KW-A	5 KW-V 2.5 KW-A	20.1 KW-V 10.2 KW-A	5 KW-V 2.5 KW-A	20 KW-V 10 KW-A
WJZ-TV	0.815 KW-V 0.800 KW-A	3 KW-V 3 KW-A	5 KW-V 2.5 KW-A	17.0 KW-V 9.0 KW-A	same as	(3)
WNBT	1.42 KW-V 1.15 KW-A	5.2 KW-V 4.2 KW-A	5 KW-V 2.5 KW-A	18.3 KW-V 9.2 KW-A	same as	(3)
WOR-TV	2.04 KW-V 2.5 KW-A	9.0 KW-V 11.0 KW-A	5 KW-V 2.5 KW-A	22 KW-V 11 KW-A	....	....
WPIX	3.5 KW-V 1.75 KW-A	16.3 KW-V 8.17 KW-A	5 KW-V 2.5 KW-A	26.3 KW-V 13.2 KW-A	5 KW-V 2.5 KW-A	20.8 KW-V 10.6 KW-A
WATV	5 KW-V 2.5 KW-A	30.5 KW-V 15.3 KW-A	same as	(2)	5 KW-V 2.5 KW-A	22.5 KW-V 11.8 KW-A

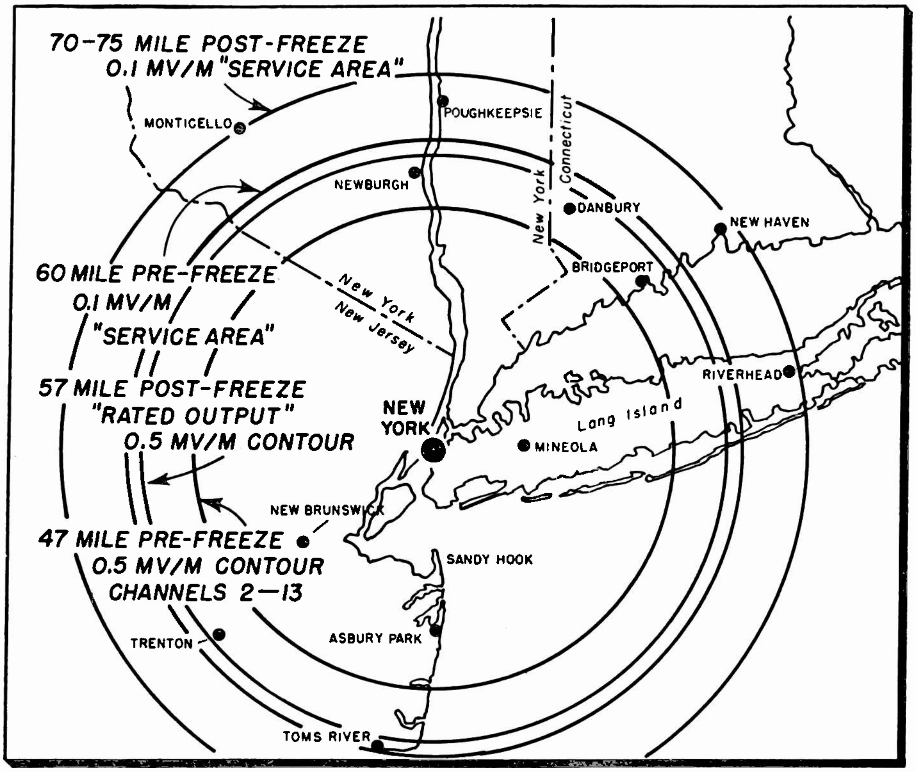
Unique Antenna Installation

now possible for to service area

within the FCC's 50 kw at 500 ft. figure. As reports are received from other stations and final measurements are made it will be interesting to compare the effect of raising the powers of other low power artificially limited stations.

When WATV commences operation from the Empire State Building, it is expected to use a series of dipoles mounted around the base of the tower in much the same manner as WCBS-TV is using at present. Perhaps the results of using channel 13 at this height and with high power will present some extremely interesting phenomena in the field of long distance reception.

The comparison between the Empire State transmissions and those from WOR-TV's antenna in North Bergen may point up the effect of an increase in height, i.e. the difference between the WOR tower and the Empire State Building. However, the effect of frequency will be eliminated since the Empire State Building transmissions occur on frequencies which bracket that of WOR-TV.



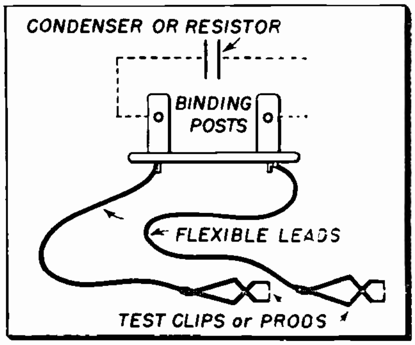
Expanding service area as seen by TV stations in New York City during last 3 years

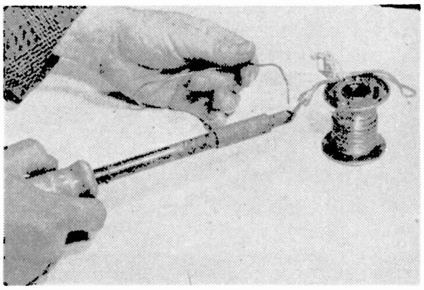
The only revised coverage map thus far available is from WOR-TV and is based on the increase in power and was compiled by means of increased mail response after the event. As soon as WCBS-TV and WABD join the tower it is expected that revised coverage maps will be available.

Service Shortcuts

Substitute Condensers

Everyone at some time has found it necessary to substitute a condenser or resistor in a circuit momentarily to test the part in question. The usual method is to hold the substitute in your hand, or tack it in with a soldering iron. The test fixture shown enables the servicer to insert a condenser or resistor between two binding posts, and with the aid of two flexible leads and clips, to make positive contact. This eliminates the need for soldering, or the hazard of holding the part. Should it be necessary to make contact at a difficult location, the clips can be clipped on long insulated screwdrivers or regular test prods.—*Grant Nonnamaker, Grant's Radio, 6548 Torresdale Ave., Philadelphia 35, Penna.*





Soldering Tip

From R. Whitman, Greenwich, Conn.: When soldering leads on RCA phono jacks, speaker plugs, Amphenol plugs and the like, most people hold the tip upside down and try to melt solder down into it. This gets a lot of solder on the outside of the pin, but very little inside where it is needed. I have found the following method very easy, secure and neat: Put the tip *down* on the iron and heat it a bit. Then tip it slightly so that the opening in the bottom is slightly exposed, and put the solder on the iron at this point. The hot tip will draw the solder *up*, with none on the outside. The jig I use to do this (as shown in the photo) is simply an alligator clip to hold the lead down in place. You can also set the iron in a stand and hold the lead down on it (hold it with a long nose unless your hands are pretty tough).

Designing

By *JOHN H. BATTISON*
Consulting Editor

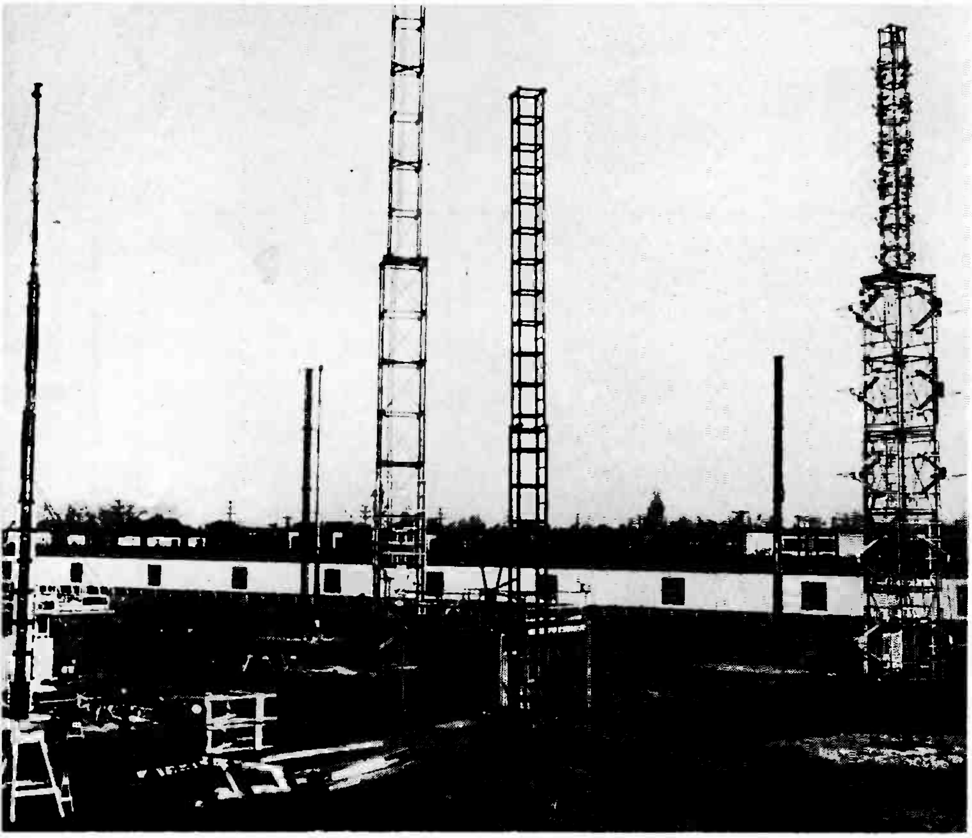
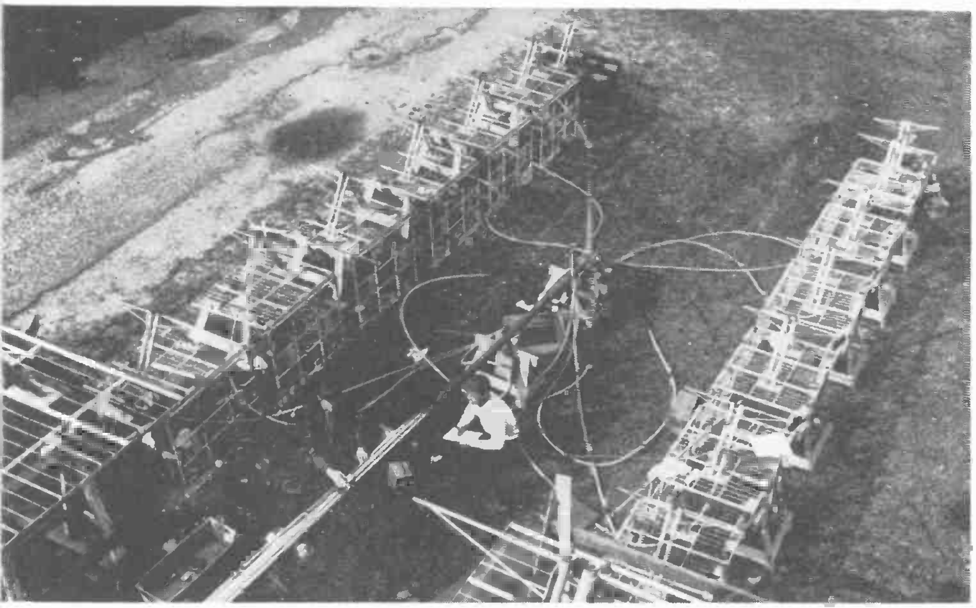
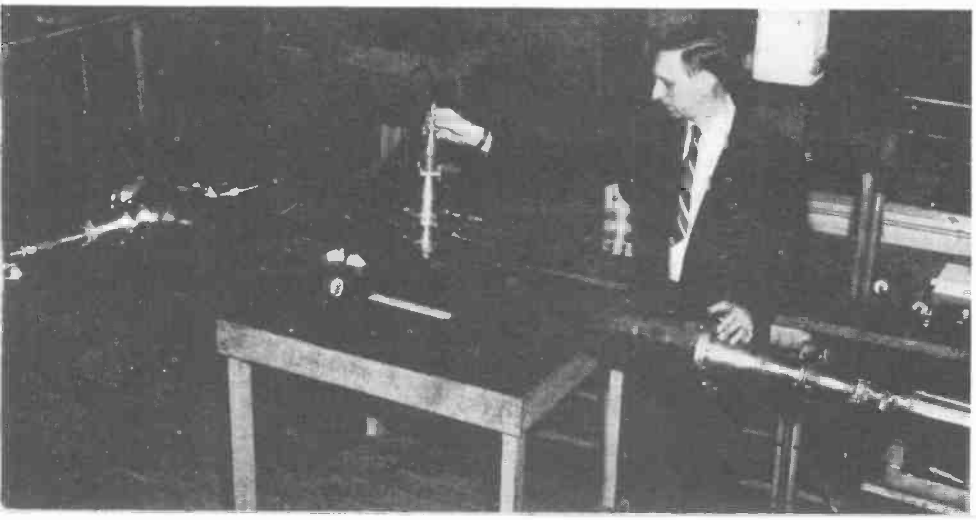


Fig. 1: Test towers at RCA, Camden. Foreground tower will support antennas for channels 7 and 11; left to right are antennas for channels 11-4, 2-5, and 5-7.

Fig. 2: SWR. measurements made on ch. 7 radiator with ch. 5 antenna adjacent to it.





WHEN the decision to install more than one television station on the Empire State Building was made, the primary consideration was interaction between stations. The first expectation was that four telecasters would share the new tower; however, later this figure was increased to five. In the antenna design only interaction between antennas can be considered. To date some preliminary tests have been made on the coupling between adjacent antennas which indicate that a decoupling of the order of 26 db can be achieved. This figure was obtained on the basis of previous experience.

Probably the only good feature of the late November and early December hurricanes experienced in the east was the very thorough workout and lifetest it gave the test antennas at the Camden plant of the Radio Corporation of America. Fig. 1 shows a general view of the test ground with the antennas mounted on towers to simulate the actual proximities to be encountered in practice. Rain, snow, heat and cold as well as fumes and corrosive air about as bad as that encountered in New York have impinged on these radiators but they have withstood all that the elements can do. In New York City, also, the steelwork received a workout when the hurricane hit town, but from all reports no trouble was encountered.

The location of the antennas has already been discussed in the November issue of TELE-TECH (cover), it is their close proximity which was expected to present many difficulties in connection with isolating the antennas. Many tests have been carried out to determine the amount of interaction between the adjacent antennas.

In order to simulate actual conditions on top of the Empire State Building as nearly as possible, four test towers were built on which each pair of adjacent antennas will be mounted. This test will yield impedance data over the channel as well as the amount of interaction. It also simulates assembly problems on top of the building. Four towers

←
Fig. 3: 20 Kw diplexer and equalizer unit for the lower channel radiating system.

World's Highest TV Antennas

Many problems concerning interaction between adjacent antennas are solved in the TV-FM transmitter installation on Empire State Building

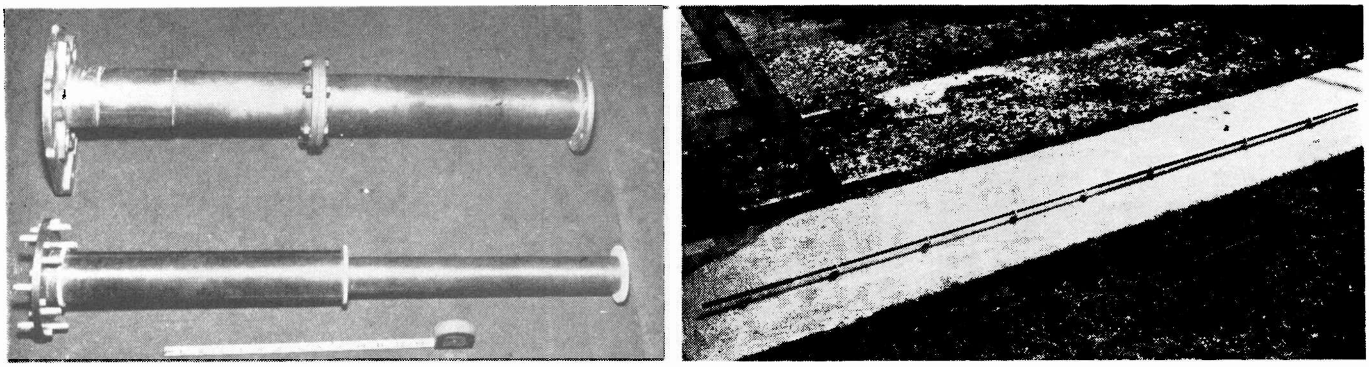


Fig. 4: Left, closeup of a feed line transformer and junction box. Right, triplexing transformer for channel 4 radiator.

are needed for Channels 2 and 5, 5 and 7, 7 and 11, and 11 and 4.

In each test operation signals at the visual and aural frequencies were fed into the deplexer and passed through the power equalizer (if required) and then to the antenna. In the antennas tested both antennas are assembled completely. An Oscillator is fed into one antenna and a field intensity meter is connected to the other to determine the amount of coupling. When the proper frequency is applied to the transmitting antenna the amount of power pickup by the adjacent antenna is measured. A figure of 26 db down is considered satisfactory.

Types of Antennas

The antennas used are of two types; channels two, five, seven and eleven use the RCA U Super gain antenna while channel 4 uses the RCA Super Turnstile antenna. For stations WCBS-TV and WABD special emergency antenna switching arrangements are used so that the antennas can be operated as either 2, 3, or 5 bay radiators. The reason is presumably to allow emergency operation in the event that trouble occurs in the whole system. The antennas are split and separate transmission lines, diplexers, and power equalizers, are used for each section. In normal operation the power is divided as shown in Fig. 5 and all sections are used, but if trouble develops in either section it can be cut out and the transmitter operated into the good unit. Switching is manual and carried out simply. It is understood that the other stations have different emergency facilities so that this feature will not be used.

Stations using the Super Gain antenna were given their choice of single-line or double-line feed. The low band stations chose single-line feed while the high band chose double-line feed. Low-band stations will use a bridge-type power equalizer which tends to broad-band the antennas. Broad banding problems are more severe on the low bands since Channel 2, for instance, occupies a 10% band width compared to 3% for Channel 11.

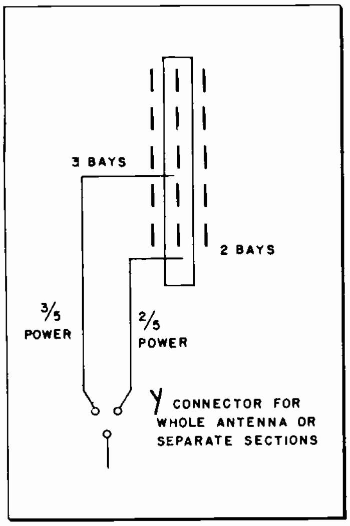
For most of the antennas the feeders running from the junction boxes illustrated in Fig. 7 are RG 35/U with the metal armour removed. However in some of the illustrations RG 35/U with the braid still on it is shown. The impedance is 75 ohms.

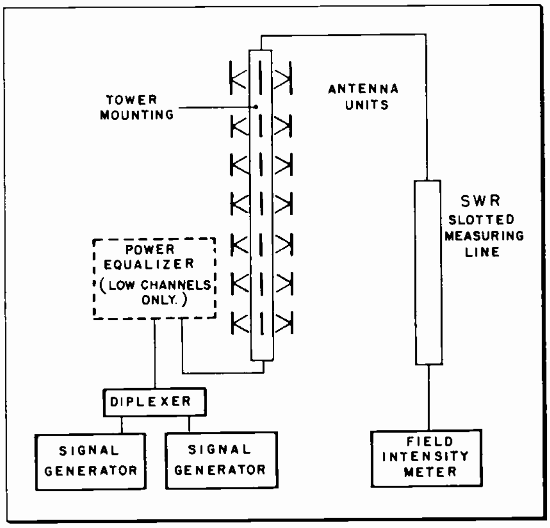
Few of the mechanical details of tower construction appear to have interfered with the electrical design of the antennas, in fact that the only one which has been discussed was the need to reduce the width of the channel 11 reflectors due to the small size of the latter, and the large (about 8 inch) steel angle which comprises the sides of the tower at this point. Thus it became necessary to simulate these solid reflectors by the use of sheet metal during the tests.

The pole for mounting the channel 4 Super Turnstile presented a problem inasmuch as it had to be cut into ten foot lengths to get it in the elevators and up to the top of the Empire State Building. The connections to the Super Turnstile Antenna are unusual in that flexible RG 35/U is used rather than the normally used rigid copper transmission lines. The turnstile type of antenna had

(*Continued on page* 48)

Fig. 5: (Left) Switching system provides whole or partial operation of low band antennas. Fig. 6 (Right) Set-up to measure degree of interaction between antennas.





UHF-Converter Design Features

More recent manufacturer's data provides additional details on technical characteristics of TV tuners.

Mallory Converter

Utilizing a recently developed type tuner, this converter, designed by P. R. Mallory & Co. Inc., Indianapolis 6, Ind., covers the r-f range of 470 to 890 MC. The tuner used in this converter is of the three section type. It consists basically of two r-f circuits overcoupled to provide a relatively constant band width, and the third section being used for the local oscillator which tunes 82 MC below the r-f band. The output of the oscillator is connected to a crystal diode as well as the incoming r-f signal. The output of the crystal goes to a low noise triode r-f amplifier which has a single broad tuned circuit in the input and a double tuned circuit in the output. The band width of the output circuit is approximately 12 MC wide so that it will cover the adjacent channels of 5 and 6. The choice of channels 5 and 6 was made because it was felt that a better noise figure could be obtained on the low TV bands, and also that the switch problem would be slightly easier. The output of the converter being at an r-f frequency of 5 and 6 enables it to be connected to any present day TV receiver.

The power supply is of the transformer type using a tube rectifier and is strictly conventional. The on-off switch serves a dual function in that it switches the VHF antenna straight through the converter to the receiver antenna terminals when in the off position. When the converter is turned on the output of the converter is connected to the VHF receiver. The UHF antenna is not switched, but is connected to the first tuned circuit at all times. A 110 volt receptacle is provided on the back of the converter so that the television receiver may be plugged in and thus turned on and off with the converter. Installation of this converter is comparable to that of installing a booster on a present day TV receiver.

Stromberg-Carlson Converter

The new UHF television converter developed by Stromberg-Carlson is designed to operate on all Stromberg-Carlson receivers as well as those of other manufacturers and to tune all of the 70 channels in the UHF band. It can be installed on existing television receivers without modification in a few minutes.

The cabinet, shown in Fig. 2, is styled in green leatherette and proportioned to harmonize with the television receiver. The outside dimensions are approximately 8 in. wide, 4 in. high and 6 in. deep. The unit weighs 5½ pounds and has a power consumption of about 10 watts. Channel indicator, vernier tuning knob and function switch are all located on the right side of the unit.

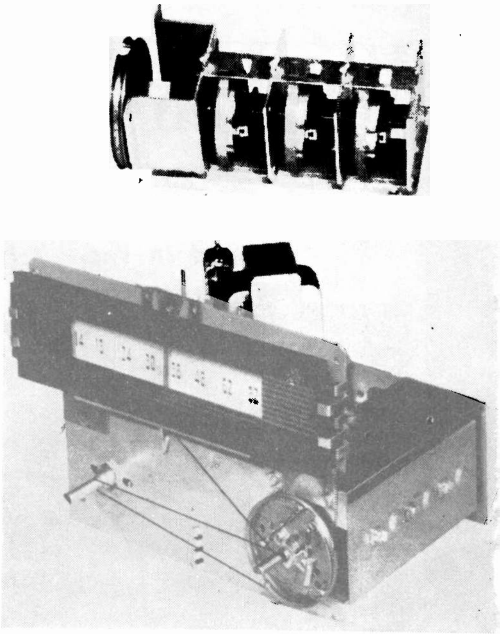
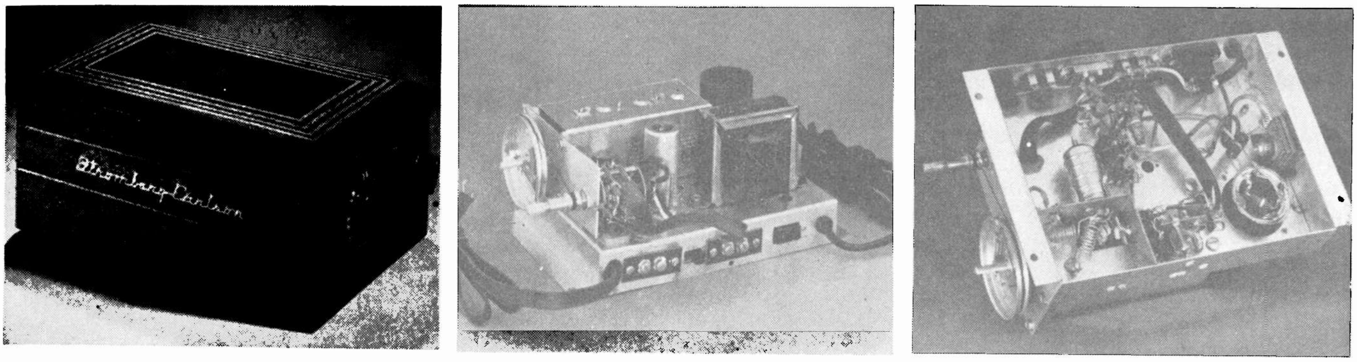


Fig. 1: (Above) Three section tuner used in P.R. Mallory's UHF-Converter (Below)

Top and bottom views of the chassis are shown in Fig. 3 and Fig. 4. The converter is designed for connection between the antenna lead-in and the television receiver. Receiver power is obtained from a socket in the rear of the converter chassis which in turn is plugged directly into the ac line. A single three-position function switch provides the following combinations: 1. Off—Both converter and television receiver; 2. VHF—a-c power to television receiver on, VHF antenna directly connected to television input. Converter heaters on. 3. UHF—a-c power to both units and choice of separate UHF antenna, VHF antenna or built-in cabinet antenna depending upon signal conditions.

The converter can be operated by tuning the receiver to either of two channels (#5 or 6) which is not occupied by a local station. This choice is made during installation by a switch in the rear of the converter chassis, which shifts the first IF tuning 6 MC. The bandswitch of the UHF pre-selector circuits is 12 MC., allowing this shift without loss of tracking. Selection of this IF is a compromise providing a mean between the extremes of the high noise factor in the high channels and the undesirable spurious responses of the very low frequency channels. The rapid attenuation with increasing distance of UHF signals which might cause spurious interference

Figs. 2-4: (Left) Overall view of the Stromberg-Carlson UHF converter. (Center) Top and (Right) bottom view of chassis



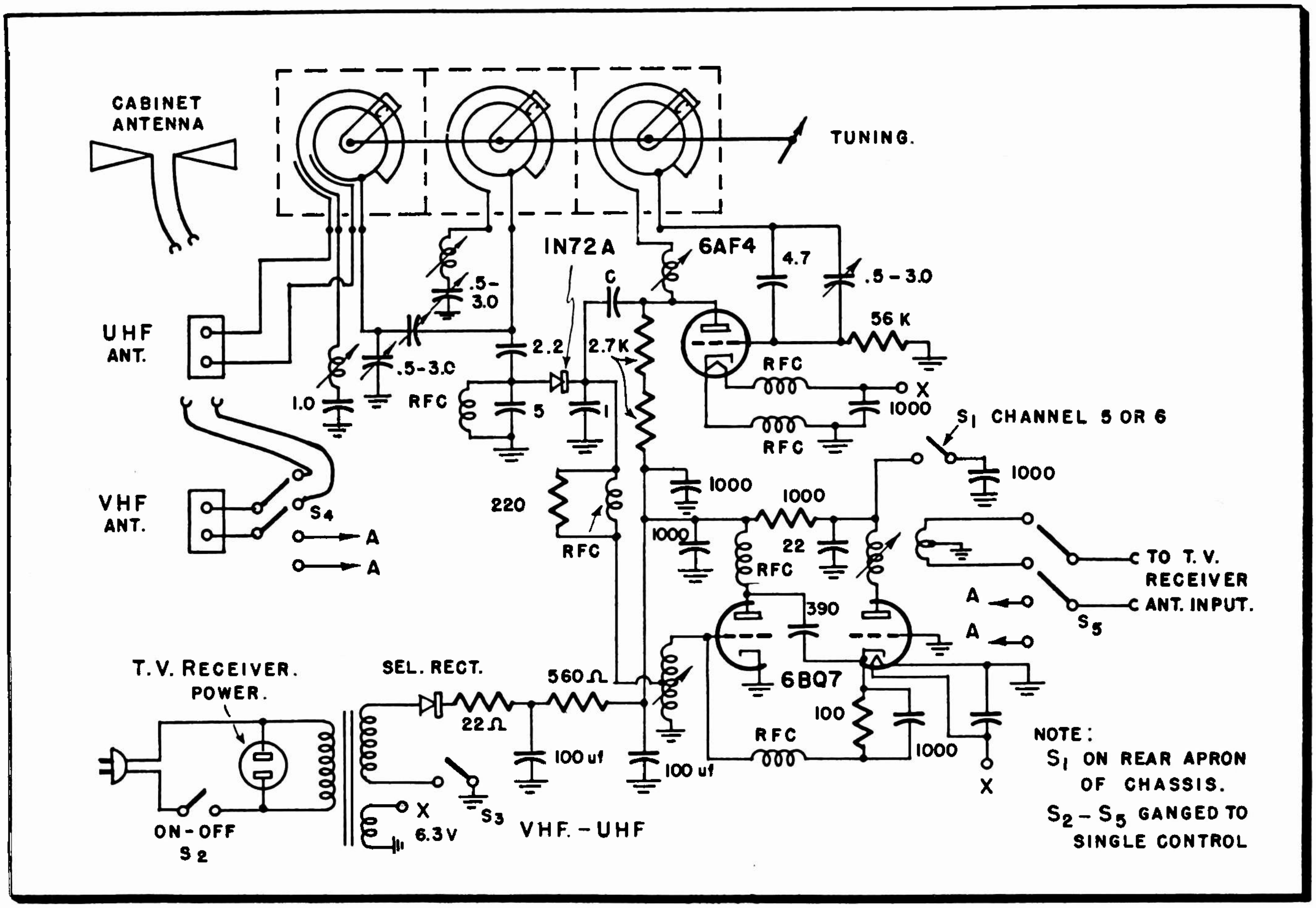


Fig. 5: Schematic diagram of the Stromberg-Carlson UHF-Converter

appears to make it practical to use a lower IF than would otherwise be possible.

Mixer Circuits

In both the antenna and mixer circuits, the tuning elements are inductively padded in order to secure the proper tuning range. This is accomplished by extending both conductors of the antenna section and one of the conductors of the mixer section about ⅞ in. external to the tuning unit. The balanced 300-ohm antenna is coupled into the extended section of the tuning unit with the aid of an ungrounded loop.

A combination of high-side capacitive and inductive coupling is used between the antenna and mixer tuned circuits in order to provide a bandwidth of 12 MC. throughout the UHF band. The 1N72 crystal mixer is coupled capacitively to the mixer tuned circuit, and an RF choke provides a d-c return path for this circuit. (See Fig. 5)

Grounding of the low frequency ends of the antenna and mixer lines and the grounding of the rotor of the antenna section eliminate spurious suck-outs within the band.

The oscillator design utilizes a miniaturized version of the 6F4. A series trimmer condenser effectively sets the low frequency end of the tuning range, and a series trimmer inductance consisting of the grid and plate leads control the total range and the high frequency limit. This adjustment consists of varying the separation between these leads. "Holes" in the frequency range are avoided by using resistors rather than chokes in the plate and grid return circuits and by using dissimilar chokes in the cathode and ungrounded heater leads. A special UHF low-capacity tube socket is used to prevent bypassing the tuned circuit by the grid-plate socket capacity.

Tube "warm-up" drift, although somewhat a function of individual tubes, is nearly complete within one minute after application of plate voltage, with heaters previously warmed up. This initial drift is minimized by using the lowest plate power which will give reliable performance.

Complete shielding of the oscillator tube, circuit, and tuner section together with low oscillator plate voltage reduces oscillator radiation.

The conversion loss of the crystal mixer is overcome by the addition of a low noise amplifier. A "cascode" circuit using a 6BQ7 tube was selected because of its inherently good noise factor. This circuit consists of a neutralized grounded cathode input section followed by a grounded grid stage.

Both the input grid and the interstage circuit of the cascode are adjusted to have bandwidths of about 12 MC., i.e., to include both Channels #5 and 6. The plate of the output triode, however, is adjusted for a 6 MC. bandwidth and a switch is provided on the rear of the chassis to select the desired channel. Economy is achieved by the use of a simple slide switch as a channel selector which varies the value of capacity in series with the plus B end of the plate tuning coil. Balanced output is used in order to eliminate interference pickup on the lead coupling the converter to the VHF receiver.

Since most television receivers have no provision for supplying power to an external converter, this converter is self-powered. Both chassis height limitations and power economy dictated the use of a selenium rectifier in preference to a vacuum tube, but a power transformer is used to eliminate hum interference between converter and television receiver.

AC power for the television receiver can be secured from the rear of the chassis, and a switch on the converter energizes both units and selects either VHF or UHF reception.

The heaters of the converter tubes remain on for both types of reception with a plus B switch being provided in the ground return of the power transformer secondary. Switching in this manner allows instantaneous change from VHF to UHF and also removes the voltage from the converter filter condensers during VHF operation.

Input terminals for both VHF and UHF antennas are provided on the rear of the chassis. When receiving signals on Channels #2 to 13, the VHF antenna is directly connected to the television receiver input. For reception on Channels #14 to 84, a separate UHF antenna may be used, or if signal conditions allow, either the VHF antenna or a built-in cabinet antenna may be selected.

Tallest TV Antennas

(*Continued from page* 45)

to be used here since the physical size of the elements of a channel 4 Super Gain Antenna would be entirely too heavy for the tower to support at this height.

FM Operations

In addition to the television stations there will also be three FM transmitters located on the top floors of the building. WCBS-FM, WNBC-FM, and WJZ-FM will all mount their FM antennas on the tower which supports the TV antennas. NBC will use a triplexer operation taking advantage of the closeness of the TV frequency to the FM channel, and the board band width of the superturnstile antenna. WCBS-FM and WJZ-FM may use modifications of super gain antennas, but it is understood that final decisions have not yet been made and the matter is undergoing further study.

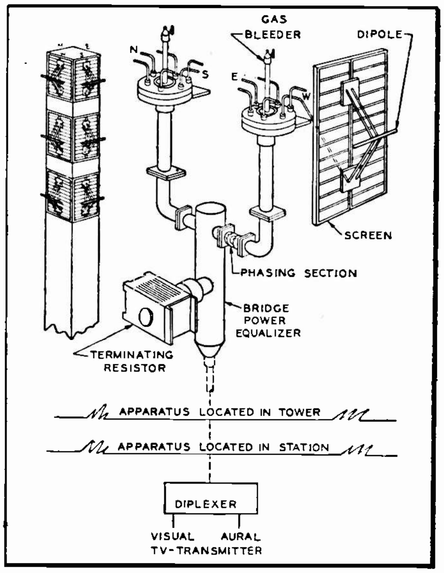


Fig. 8: Diagram of connections and arrangements of parts for phasing and exciting super gain antennas on low band channels.

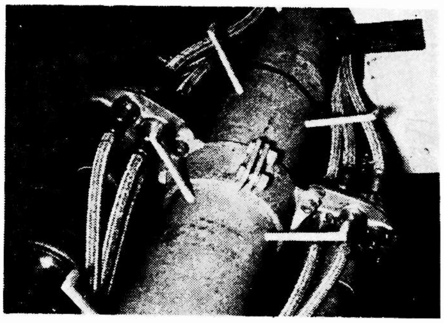


Fig. 7: Junction boxes on channel 4 center pole. Later, outer braid was stripped from the RG/U coaxial cable transmission line

SHOP HINT

TV Bias Source

(*Continued from page* 27)

ing TV sets is shown. It makes use of a dual control of the type used in TV sets, one section 10K ohms and the other 3500 ohms. The two sections are connected in series and provide a coarse and a vernier adjustment for accurate control of the voltage. The control I used is an RCA replacement which also has a switch. I use this to break the negative lead of the battery, thus removing the load from the battery when not in use.—*Robert Seymour, 567 Elm Grove Drive, Elgin, Illinois.*

COLOR-TV TABLE

(*Continued from page* 9)

(10) To allow present receivers to receive color transmissions in color.

(11) Quality comparison of monochrome picture from color transmission with monochrome picture from monochrome transmission.

(12) These changes do not consider the use of single trichromatic cathode ray tubes. In columns 108M and 108C letters a to i mean the following:

- a. Change H and V sync components.
- b. Change H and V deflection components.
- c. Make power supply adequate, including hum protection. Subcommittee members disagreed on the necessity for this, without further tests.
- d. New high-voltage circuits.
- e. Add dot modulator with its power supply.
- f. Add color phaser. This is optional, since phasing may be accomplished manually.
- g. Add color disk and drive and synchronizer.
- h. Add magnifier (optional).
- i. Add video projection unit, including color switching circuits and associated power supply.

The above list of modifications presumes a picture of minimal brightness and 10-inch size with a magnifier.

(13) The performance is substantially equal to that of system A1. There may be slight degradation on strongly colored objects.

(14) Mr. Smith reports that the receiver noise becomes more visible in fringe areas. Also that the resolution becomes poorer. Mr. Goldmark does not concur with this, but proposes further tests to clarify the question.

(15) This assumes that the receiver takes advantage of dot interlacing.

(16) This applies when using single tube and color disk. Flicker may be roughly equal to standard black and white when using three long persistence phosphors and projection type receiver as in CBS demonstration of April 26, 1950.

(17) This applies to interline flicker and crawl. Present information is insufficient to evaluate inter dot flicker and crawl.

(18) Superior for most objects. In areas of pure primaries (red, blue or green) inferior by a ratio of 48 to 60.

(19) Same as system C2 when using receiver with single tube and color disk. Absent when using three long persistence phosphors and projection type receiver as in CBS demonstration of April 26, 1950.

(20) Present monochrome receivers will receive transmissions with detail equal to that of system C2. It may not be practicable to add equipment for dot interlace reception to receivers now in the hands of the public.

(21) The receiver will need the following additional equipment: Inverse sampler; picture translator; power supply.

(22) Present information is insufficient to evaluate effects of inter-dot flicker and crawl and of dot structure in picture. Otherwise the answer is "equal."

(23) Receiver will need following additional equipment: Three-channel video amplifier, picture translator, power supply.

(24) Present information is insufficient to evaluate effects of fine grain pattern in picture. Otherwise the answer is "equal."

(25) These figures apply to normal subject material. With certain special test patterns the resolution may be less. With a standard test chart printed in black on a background of one of the primary colors, the color of the background in the vertical wedge will desaturate progressively toward the fine end of the wedge. The same test chart printed in one primary color on a background of another primary color will show decrease of detail in the range corresponding to "mixed highs."

(26) Due to the effect of crosstalk and spurious components, generated in this sampling process, the horizontal resolution obtainable in the individual primary color images may be somewhat less than in monochrome.