HAM NEWS

JANUARY-FEBRUARY, 1960

OPERATING G-E HI-FI TUBES AS MODULATORS

By P. E. Hatfield, W9GFS, and R. E. Moe*

The High Fidelity audio equipment boom has spurred development of several new tube types—and improvements in existing types—for audio power amplifier service. Thus, amateurs now have a broad choice of highly efficient tubes for plate modulator service in their transmitters.

The new audio tubes shown at the right are the G-E Receiving Tube Department's new family of high-performance power pentodes designed for both monophonic and stereo high fidelity audio equipment. Keeping pace with the trend to the "pancake" shape in audio equipment, these tubes pack more power capability into compact envelopes than ever before.

A newly developed five-ply bonded plate material (see cross-sectional drawing, Fig. 1), permitted upping the plate dissipation in the 6L6-GC to 30 watts, as compared to 24 watts in the 6L6-GB and older versions. A dramatic demonstration of this new plate material's capability can be seen in the photo showing a 6L6-GB and a 6L6-GC, running side-by-side with each plate dissipating 80 watts! Note the "hot spots" — actually a bright orange in color — on the 6L6-GB plate at left. The new five-ply plate in the 6L6-GC at right is uniformly heated to a dull red color (although it appears black).

The new 7581 beam pentode — electrically similar to the 6L6-GC, but with a low-loss mica-filled base — has the five-ply plate too. Another new pentode with the five-ply plate, the 7355 for audio amplifiers in the 20-30 watt power range, packs 18 watts of plate dissipation into an envelope having a seated height of only 3 inches. The 7189A miniature pentode also has a plate made of the five-ply material.

The 6BQ5 and 7189A pentodes — plus the new 6DZ7 twin pentode, which is equivalent to two 6BQ5's in one envelope — round out

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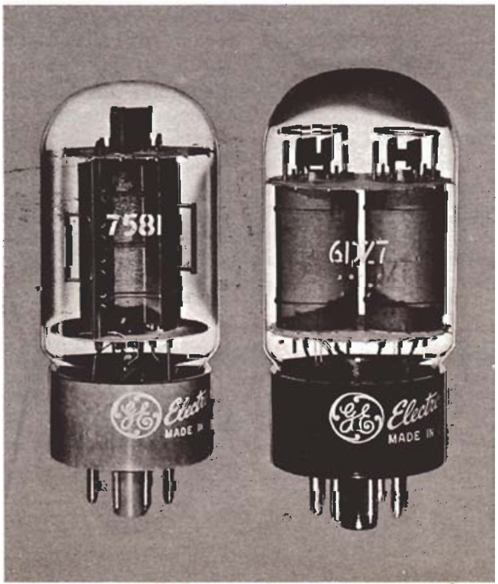
COMPARISON of plate size in the new 7355 octal beam pentode (left), and the 7189A miniature beam pentode (right). The tubes have design maximum plate dissipation ratings of 18 and 13.2 watts, respectively.

Also in this issue—

—*Lighthouse Larry*

NEW G-E 7581 beam pentode with low-loss base, and the 6DZ7 twin beam pentode (right). Both the 7581 and the 6DZ7 are only $3\frac{5}{16}$ inches in height when seated in sockets.



SCANNING *the* SPECTRUM

COMING NEXT ISSUE . . .

The TC-75, a compact 15-watt 3.8 to 4.0-megacycle mobile transmitter/converter (tucked under the dash of the author's car, above) will be described by W4QVL. This rig is only 3 inches high, 7 inches wide and 5 inches deep. It has five tubes and, with a modern external power supply, draws only 3 amperes from a 12-volt auto electrical system. Don't miss this issue, which also will announce the recipient of General Electric's 1959 Edison Radio Amateur Award for outstanding public service.

G.E.'s LME DEPARTMENT . . .

WA2ANU, K2HLT and W2OIQ, three of the authors in this issue, all hail from General Electric's Light Military Electronics Department, with headquarters in Utica, New York. This department designs and builds an impressive variety of electronic equipment for the U.S. military services.

Included in their products are armament and control systems, radar, counter-measures, communications and navigational equipment for airborne weapons. We can't go into more details here, except to say that this department also participated in the development of the synchronous communications system, better known as double sideband, and now used by many radio amateurs.

CLUB BULLETINS WANTED . . .

Among the many amateur radio club newspapers and bulletins which arrive regularly at the *G-E HAM NEWS* office, we notice some which are statewide, or section-wide in coverage. They include: *Florida Skip; Virginia Ham Bulletin,* and *The Bison,* from Indiana.

This is an excellent means of communicating news of interest to all radio amateurs in a state and, personally, I'd like to see more such bulletins published. I receive a number of newspapers from clubs in exchange for *G-E HAM NEWS.* Welcome them from clubs who may not now be sending them to me.

BRAILLE TECHNICAL PRESS ON RECORDS . . .

A "Talking Book" edition of the only radio and electronics magazine for the sightless radio amateur, hi-fi enthusiast, sound recording technician, radio and TV serviceman, is now available. This edition started with the September, 1959 issue, in celebration of the magazine's tenth anniversary.

I listened to the September record and could easily draw a schematic diagram from the oral description. Write to the editor, Bob Gunderson, W2JIO, at 984 Waring Avenue, New York 69, N. Y., for details.

Bob, incidentally, was the recipient of General Electric's 1955 Edison Radio Amateur Award for outstanding public service. He developed 30 types of auditory test instruments which opened the electronics field to the blind.

ADDRESS YOUR QSL's . . .

Make sure you fully address all QSL cards — operator's name, number and street, city, zone and state — you mail to other radio amateurs. Don't just address them "Amateur Radio W4..............., Operator Joe, Anytown, Ky.," or those QSL's may wind up in the "dead letter" file. In some post offices, there happen to be radio amateurs sorting mail, and they may watch for poorly addressed QSL cards for amateurs they know, but don't count on it!

We understand that some amateurs file a change of address form with their local post office, giving just their call letters and city as the old address, and their house number, street and city as the new address. This helps delivery of incoming QSL cards with insufficient addresses to you.

NEW ADDRESS FOR G-E HAM NEWS

In case you haven't noticed, our back-page sign-off on the last few issues has been changed from Schenectady, New York, to the headquarters of General Electric's Receiving Tube Department in Owensboro, Kentucky. Please address your communications to G-E HAM NEWS down heah, suh.

—*Lighthouse Larry*
(Colonel, that is)

ALL-BAND BALUN COIL

By Carl Byler — K2HLT*

Recently the writer was faced with two problems:

1. *Matching the pi-network (unbalanced) output of a transmitter to a doublet (balanced) antenna.*
2. *Limited finances.*

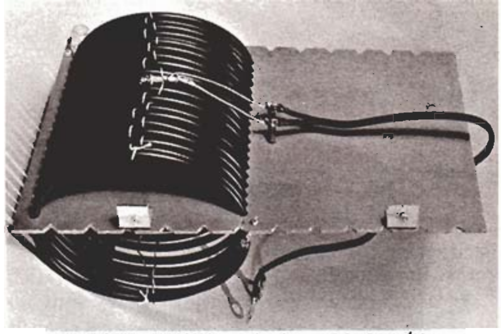
After considerable design work and testing, the All-Band Balun Coil was found to be the answer to the first problem without aggravating the second problem.

THE FEEDLINE BALANCING PROBLEM is common to many radio amateurs since the pi-network is widely employed in transmitters. It has several advantages, among them being low harmonic output to prevent interference to nearby television receivers.

Also, balanced antennas — half wave dipole (doublet), Yagi beams with split driven element, horizontal trap antenna, etc. — are very popular. Since 72 ohm transmitting twin-lead is available at a lower price than coaxial cable — especially the RG11/U type — the balun was built into the transmitter and 72 ohm twin-lead connected from the transmitter to the antenna. The placement is not critical; the balun could easily be located some distance from the transmitter and fed with a coaxial cable (but this defeats our original purpose).

This balun represents a simple autotransformer, tuned to resonance at approximately 14 megacycles by the distributed capacitance of the coaxial cable in the top half of the coil. The Q of the resonant circuit is approximately 200 (hence the low loss). When loaded with a 72 ohm load, the selectivity of the tuned circuit is broadened out to approximately a 30-megacycle bandpass. The transmitter signal is coupled, via the coaxial cable of the top half of the coil, to the bottom half, which is simply a coil to ground. However, this bottom coil is inductively coupled to the top coil (with essentially unity coupling). Each coil feeds one side of the balanced output. Since each half of the coil has equal inductance, the output will be balanced.

* K2HLT is an engineer with the Light Military Electronics Department, General Electric Co., Utica, N. Y.



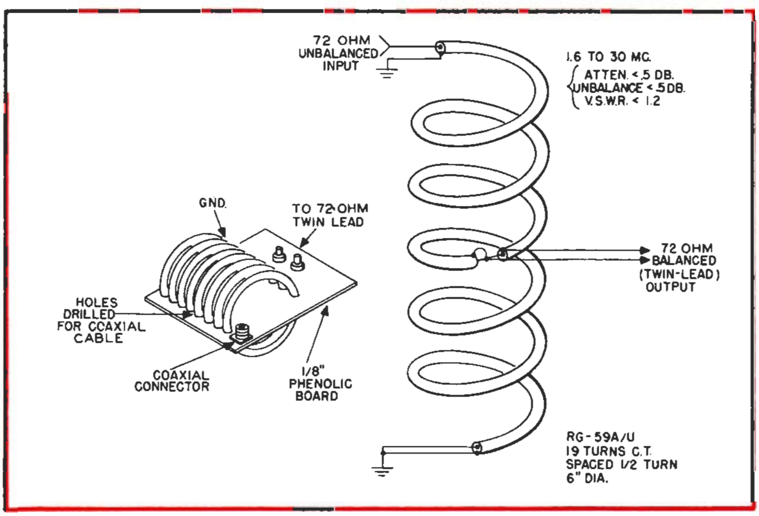
THE ALL-BAND BALUN made from RG-59A/U coaxial cable. The coil "form" is a sheet of laminated insulating board (G.E. Textolite) 15 x 9 x ⅛ of an inch thick. Two rows of 19 holes each are drilled on ⅜-inch centers, with the rows 6 inches apart. A short length of 72-ohm kilowatt twinlead runs to the antenna feedline from the terminal posts at the center of the board. Small angle brackets fasten the balun coil into the transmitter cabinet.

CONSTRUCTIONAL DETAILS for the balun coil are shown in Fig. 1 and the side view photo. The phenolic board is drilled for the cable, chassis type coaxial cable connector (SO-239) and terminal posts. The coaxial cable for each coil is threaded through the holes and then soldered connections are made. Approximately 30 feet of RG-59/U cable are required for the balun illustrated.

The RG-59A/U coaxial cable used happened to be available. Actually, the attenuation would be slightly less with a larger coaxial cable; also the maximum voltage rat-

(continued on page 6)

FIG. 1. SCHEMATIC DIAGRAM and constructional details of the balun coil. One side of the 72-ohm balanced output connects to the shield on the coaxial cable in the upper coil; the other side connects to the center conductor. Inner and outer conductors of the coaxial cable in the lower coil are connected together at each end, and grounded at the bottom end.



SIMPLIFIED COIL DESIGN (Part I)

By B. H. Baldridge, W2OIQ*

PROBLEM — HOW TO WIND COILS accurately for specific amateur radio applications. Solutions:

1. Calculating the coil inductance and dimensions from the formula

$$Lo = \frac{2.54 \times 0.03948 \left(\frac{2}{d}\right)^2 n^2K}{1}$$

— too complicated; forget it.

2. Estimating inductance with reactance charts, plus a coil nomograph. Usually after winding, finished coil must be pruned to the correct inductance value to compensate for inaccuracies.
3. Simplified graphs which can be prepared with equipment found in most amateur radio stations.

Solution 3 takes the "try" out of "cut and try" coil winding. The materials needed are: 1) Log graph paper (K & E No. 359 — 110, log 2 x 2 cycles, or equivalent); 2) calibrated receiver; 3) two-terminal oscillator (see Fig. 1 for a Franklin oscillator circuit); and 4) at least two calibrated fixed capacitors in the range of 20 and 150 mmf. Access to a "Q" meter will permit all of the measurements to be made with no additional equipment; or, a calibrated grid-dip oscillator will take the place of the calibrated receiver and two-terminal oscillator.

Suppose a coil 1 inch in diameter and 1½ inches long, having 30 turns, is available; and our standard capacitors are C_{S1} = 19 mmf, and C_{S2} = 160 mmf. Connecting the coil to the Franklin oscillator, we can find the resonant frequency by locating the frequency of oscillation. If, with C_{S1} across the coil, the oscillation frequency is measured at say 9 megacycles; with C_{S2} across the coil it would be 3.5 megacycles. This information could also be obtained by connecting the coil to a "Q" meter; or measuring resonance of the coil across the test capacitors with the grid-dip oscillator.

Plot this information on log-log graph paper and connect the two points with a straight line, as shown in Fig. 2. Note that to tune from 3.5 to 4 megacycles requires an approximate capacitance variation from 162 to 121 mmf, or a spread of 41 mmf. A total fixed, distributed and tuning condenser minimum capacitance of 121 mmf, and a variable capacitance of 41 mmf would spread the 3.5-

(continued on page 6)

*W2OIQ is a consulting engineer in the Communication and Navigation section of General Electric's Light Military Electronics Department, Utica, N. Y.

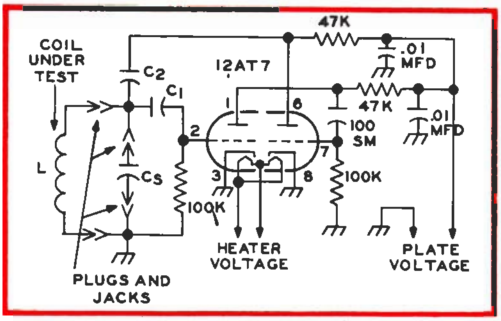


FIG. 1. SCHEMATIC DIAGRAM of a Franklin oscillator with which the measurements outlined in the text may be made. All resistances are in ohms, all capacitances are in mmf, unless otherwise specified. Capacitances C_1 and C_2 should be as small as will permit maintenance of oscillations, usually 1 or 2 mmf each. Values for C_S are given in the text.

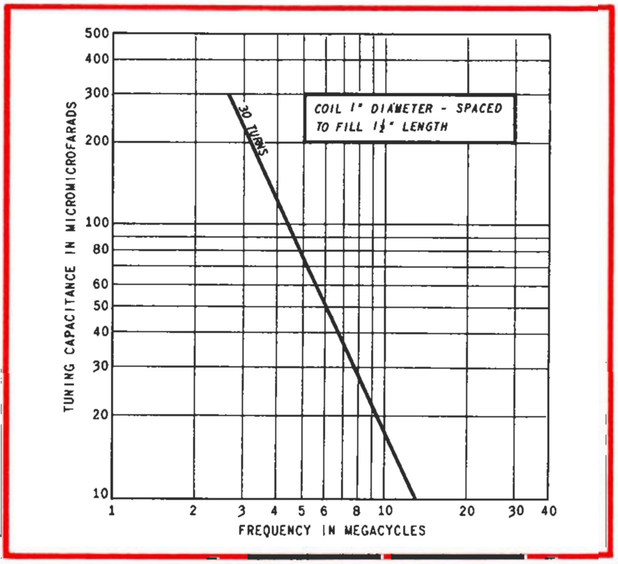


FIG. 2. GRAPH PLOTTED on log paper for a coil, 1 inch in diameter and 1½ inches long, with 30 turns equally spaced. The tuning range with a 140-mmf variable capacitor is approximately from 3.5 to 9 megacycles.

FIG. 3. EXAMPLE OF DESIGN procedure for coils 1 inch in diameter and 1½ inches long, with total turns ranging from 100 (67 turns per inch) down to 3 (2 turns per inch) turns. Accuracy is excellent up to about 200 megacycles since method outlined in text takes into account distributed capacitance and other sources of error usually neglected because of calculation difficulty.

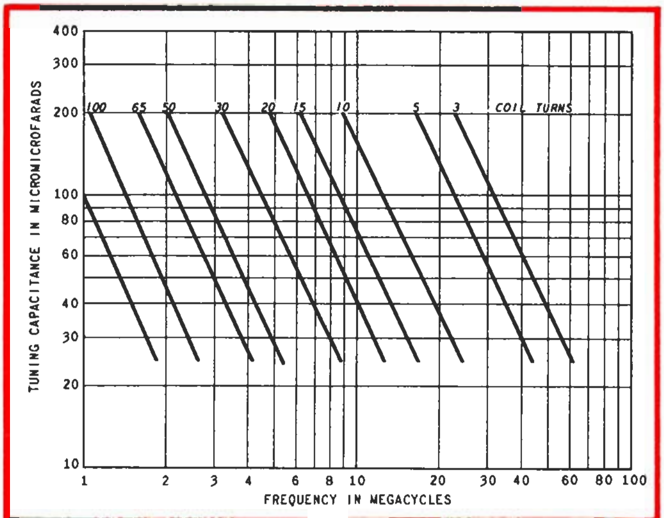


FIG. 4. FAMILY OF CURVES for coils wound on the National XR-50 slug-tuned coil form (⅜ of an inch in diameter; $\frac{11}{16}$ of an inch winding length). The area enclosed by dotted lines to the left of each solid line indicates approximate change in inductance possible with XR-50 iron slug. Copper slug produces inductance shift in opposite direction.

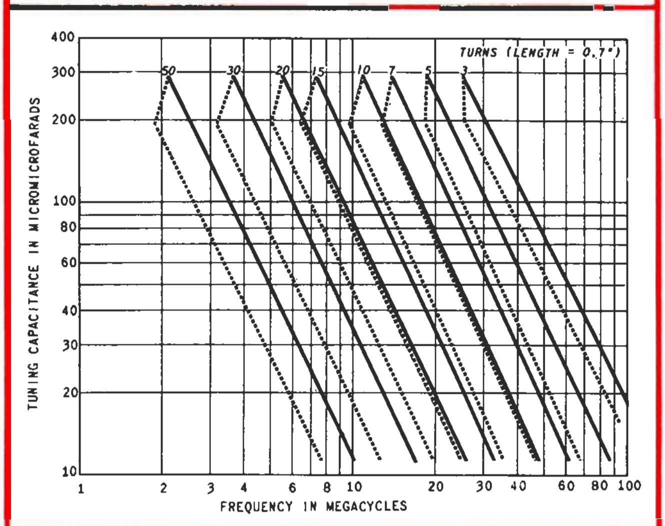
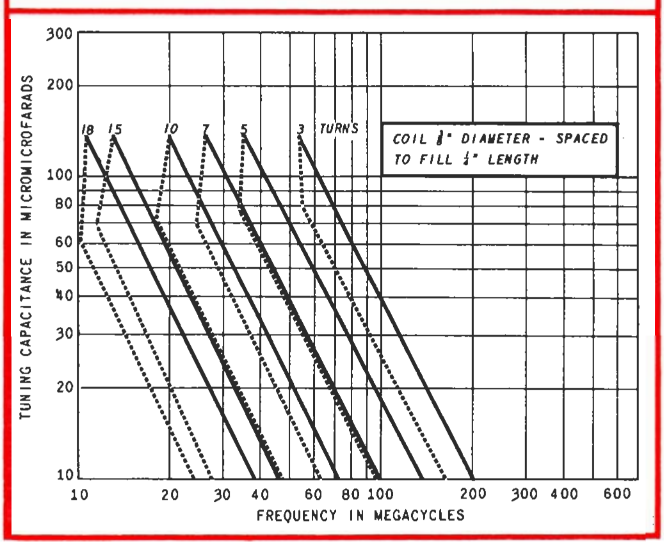


FIG. 5. COIL DESIGN CHART for Cambion LS-3 slug-tuned coil forms with combination iron/brass tuning slugs (⅜ of an inch in diameter; ¼ of an inch winding length). The solid lines indicate the inductance when the brass slug is within the coil; and, the dotted broken lines indicate the inductance with the iron slug within the coil.



SIMPLIFIED COIL DESIGN

(continued from page 4)

megacycle band over 180° shaft rotation. The same coil will tune from 7.0 to 7.3 megacycles with an approximate capacity variation from 36.5 to 33.5 mmf, or a spread of 3 mmf. A total fixed, distributed and tuning condenser minimum capacitance of 33.5 mmf and a 3-mmf variable would spread the 7-megacycle band over 180° shaft rotation. If the distribtued and input capacity add up to 12 mmf, a 150-mmf variable will tune both the 3.5 and 7-megacycle bands. A parallel 50 mmf variable and a fixed 100 mmf capacitor would make it impossible to tune the circuit to 7 megacycles, and the use of a 50 mmf variable alone would prevent inadvertent tuning to 3.5 megacycles in lieu of 7 megacycles. If the total input, output, and distributed C equals 15 mmf, the coil will tune to 10.5 megacycles and will drive a doubler to 21 megacycles.

The system can be further expanded by plotting coils with different parameters as shown in Fig. 3, which illustrates a typical family of curves for coils 1 inch in diameter and 1½ inches long.

Graphs for each individual coil of given number of turns are constructed as described. Note that the spacing between the graphs for the coils is proportional to the log of the number of turns. A slight slope change and bending of the individual coil plots is noted as the frequency approaches the natural resonant frequency of the tuning element, due to the increased proportional effect of the distributed capacitance, coil leads and terminals, and other factors impossible to eliminate and difficult to calculate in practical coil problems. These factors are usually neglected on impedance charts, making the charts useless for practical applications requiring accurate construction of small inductances.

Precise determination of coil parameters can be obtained by limiting the use of a given chart to a 10-to-1 turns ratio when determining coil parameters from data taken with coils of a few turns. Figs. 4 and 5 show a similar family of curves for widely used commercial coil forms. The inductance variation made possible by positioning the slugs is illustrated by the dashed lines.

A useful chart for clipping coils such as B & W Miniductors can be made from a couple of assorted lengths of the size in question. The fact that length and number of turns are changed simultaneously does not void the chart; the slope remains the same but the spacing between graphs of the coils will be slightly changed.

Any number of similar charts may be rapidly prepared. From two or more experimentally plotted graphs of individual elements approximately within the desired range, a family of curves may be drawn to permit accurate selection of the desired tuning elements. Frequency doublers or power amplifiers thus may be accurately ganged.

Note that for a small increment of frequency, such as a typical amateur band, the use of fixed capacitors to set the operating point and a small variable straight line capacitance will give essentially straight line frequency tuning. The ganging of circuits with straight line tuning is no problem. As charts for progressively larger power coils or doubler coils all have the same slope, the choice of capacitors and inductors to gang and track tuned circuits becomes elementary.

(Part II will appear in a subsequent issue — Ed.)

ALL-BAND BALUN COIL

(continued from page 3)

ing (2300 volts for RG-59A/U) would be higher. However, the loss in this model is negligible and the voltage is low (under 1300 volts peak to peak for a one-kilowatt amplitude modulated transmitter) as long as the balun is kept loaded.

Other 72 ohm coaxial cables, such as RG-8/U, RG-11/U, RG-12/U, RG-13/U, RG-15/U, RG-34/U, and RG-35/U may be used in a balun of this type. The coil usually must be redesigned to compensate for the different characteristics of the cable, such as the outside diameter. The procedure in this case would be to adjust the length and size of the coil to resonate at 14 megacycles, while maintaining the required bandwidth under loaded conditions.

This balun was tested with both low level (signal generator) and high level (pair of 813's plate modulated by a pair of 813's) signals. From 1.8 through 30 megacycles, the voltage standing wave ratio (V.S.W.R.) was measured to be less than 1.2:1. The unbalance and insertion loss were measured and found to be less than 0.5 decibels.

The balance was checked with high power by attaching two 200-watt light bulbs — one on each side of the 72 ohm balanced line to ground. The transmitter lighted both bulbs equally to full brilliance with less than 500 watts DC input to the 813's.

As proof of the pudding, the writer finished and installed the assembly about 10 o'clock on a Friday night. After loading the transmitter through the balun into a simple doublet antenna, he called "CQ" on the crowded 14-megacycle phone band. Before retiring at 11 o'clock, numerous QSO's were completed, with the weakest signal report received being 10 db over S9 from San Francisco.

HOW TO GET *G-E HAM NEWS* . . .

G-E HAM NEWS is available free of charge if you pick it up from your local **G-E** Tube distributor. Some distributors mail copies locally to their customers. Or, for those who prefer receiving copies directly from us, we have a low-cost subscription plan at $1.00 per year. Order your subscription from: **G-E HAM NEWS**, General Electric Company, Receiving Tube Department, 316 E. Ninth Street, Owensboro, Kentucky, U.S.A.

OPERATING G-E HI-FI TUBES AS MODULATORS

(continued from page 1)

this hi-fi tube family. These tubes normally are rated in the technical data for push-pull class AB_1 operation at low harmonic distortion — about 2 percent — in high fidelity amplifier service. These ratings are given in the "Hi-Fi Service" columns in Table I.

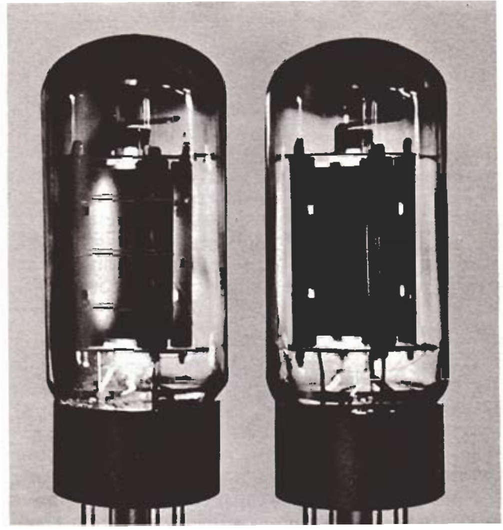
Plate modulator service in amateur transmitters, however, usually permits the audio power tubes to be operated with higher distortion — up to about 10 percent — in the output. This allows the modulator tubes to be driven harder — up to the maximum ratings — with a resultant 25 to 90-percent increase in power output, depending on tube type.

A session with the "OPERATION CHARACTERISTICS" curves on the *DESCRIPTION AND RATING* sheets for these tubes resulted in the figures listed in the "Modulator Service" columns in Table I. These operating conditions are all within the "MAXIMUM RATINGS" listings for each tube type. A typical class AB_1 amplifier circuit is used to obtain this data.

A 24-watt modulator with a single tube output stage can be built around a 6DZ7 twin pentode, operated with 400 volts on the plates. Or, a pair of 6BQ5's can be substituted if desired. For high power output at a moderate 400 plate volts, a pair of 7355's will deliver 54 watts of audio power. These figures do not include output transformer losses.

Plan your new plate modulator around the above tubes. As makers of high fidelity equipment can verify, they really deliver the watts, and with low distortion too.

*W9GFS is an engineer in the Technical Data Unit, and R. E. Moe is the Manager of Engineering in General Electric's Receiving Tube Department, Owensboro, Ky.



UNRETOUCHED PHOTO showing a 6L6-GB (left) and a new 6L6-GC (right) with five-ply bonded plate material, each operating at a plate dissipation of 80 watts. The 6L6-GB has "hot spots" on the plate, bright orange in color, while the plate of the 6L6-GC shows only a uniform dull red, due to the superior heat dissipating characteristics of the new material.

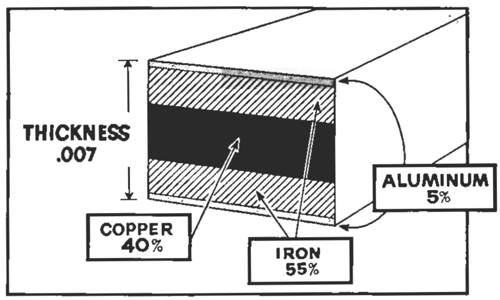


FIG. 1. CROSS-SECTIONAL VIEW of G. E.'s new five-ply bonded plate material. The metal "sandwich" gives better heat conduction and radiation than conventional single-layer anode materials.

TABLE I — COMPARISON OF HI-FI AND MODULATOR SERVICE

PUSH-PULL CLASS AB_1 AMPLIFIER, VALUES FOR TWO TUBES

TUBE TYPE	1 — 6DZ7 2 — 6BQ5 2 — 7189A		2 — 6L6-GC 2 — 7581		2 — 7355		
	Hi-Fi Rating	Mod. Rating	Hi-Fi Rating	Mod. Rating	Hi-Fi Rating	Mod. Rating	
Plate Voltage	400	400	450	450	300	400	Volts
Screen Voltage	250	250	400	400	250	300	Volts
Grid-Number 1 Voltage	—11	—11	—37	—37	—21	—32	Volts
Peak AF Grid-Number 1 Voltage	22	26.4	70	85	42	70	Volts
Zero-Signal Plate Current	80	80	116	116	100	72	Milliamperes
Maximum-Signal Plate Current	100	110	210	240	185	244	Milliamperes
Zero-Signal Screen Current	4.0	4.0	5.6	5.6	5.5	4.6	Milliamperes
Maximum-Signal Screen Current	13	16	22	30	24	30.4	Milliamperes
Effective Load Resistance, Plate-to-Plate	9000	9000	5600	5600	4000	3500	Ohms
Total Harmonic Distortion[1]	2.5	5	1.8	7	2.0	5.8	Percent
Maximum-Signal Power Output[2]	18	24	55	70	28.5	54	Watts

[1]Without feedback.
[2]Power output figures quoted do not include losses in output transformers usually encountered in practical circuits.

A FEEDLINE TEST FOR TRANSMITTER PARASITICS

By D. T. Geiser — WA2ANU*

TRANSMITTERS that are stable under CW or no-modulation conditions sometimes break into parasitic oscillation or other instability when amplitude modulated. The test described here has proved useful in checking for instability during modulation peaks.

Ideally, transmitters should be tested feeding dummy loads before on-the-air operation. If such a test is made, one simple additional test permits a simultaneous check for parasitics. This modification consists of shunting the dummy load with a parallel-tuned circuit. If tuned to the operating frequency and having a moderate Q, the added circuit is electrically invisible at the desired frequency but very much in evidence at other frequencies.

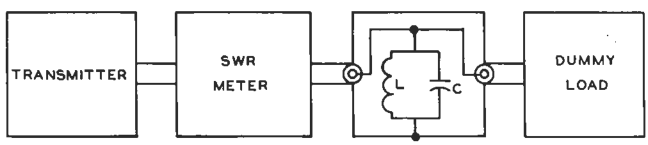
Thus a standing wave ratio (SWR) bridge will indicate a normal standing wave ratio if only a pure modulated output wave is present. If parasitics or off-frequency oscillation occurs during modulation, the SWR meter will kick because the tuned circuit (L-C) is not resonant at other frequencies. The test circuit used successfully at WA2-ANU is shown, Fig. 1.

If an antenna system is matched to a low standing wave ratio and resonant, the SWR meter by itself may be used to show the presence of spurious output on the feedline.

This test is mainly useful to check massive errors and should not be considered a valid check for very low power parasitics and harmonics.

*WA2ANU is a components engineer with General Electric's Light Military Electronics Department, Utica, N. Y.

FIG. 1. BLOCK DIAGRAM of parasitic test circuit. Tuned circuit L/C is tuned to the operating frequency. Capacitor C should be about 5 mmf per meter (400 mmf for 80 meters; 40 mmf for 10 meters). Off-frequency emissions are shown up by an indication of reflected power on the SWR meter.



HAM NEWS

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E. A. Neal, W4ITC — Editor

BUILD-IT-YOURSELF IDEAS from the 999 radio amateurs at GENERAL ELECTRIC

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