Electronic TUBES

Ham News

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MAY-JUNE, 1953

VOL. 8—NO. 3

The DIOPLEX

. . . replaces the antenna relay in 50-ohm coaxial circuits

Contents

THE DIOPLEX

Here's the answer to the prayers of many a ham—an electronic circuit without switches or relays that permits a receiver to remain permanently connected to a transmitting antenna without damage to the receiver when the station transmitter is turned on.

The Dioplex taps into the transmission line and permits low-level incoming signals to pass into the receiver. However, when the transmitter is operating, the relatively high level signal voltage which appears on the line activates the Dioplex in such a way that the path to the receiver is blocked. Two words of caution at the outset: The unit is designed for 50-ohm coax; and as the operating frequency increases, the power-handling capacity of the Dioplex rapidly drops off. Of course, 80-meter boys are limited to 5000 watts!

—*Lighthouse Larry*

The Dioplex is a device for connecting a receiver to a transmitting antenna to obtain the advantage of as good an antenna for receiving as for transmitting. This is accomplished without moving parts—no relays with their clatter and possible erratic contacts to cause unexpected trouble. Since the action of the Dioplex not only is silent but instantaneous and positive, the receiver input circuits are afforded an even higher degree of protection from accidental or inadvertent damage than when a separate receiving antenna is used.

The Dioplex is used between a low impedance transmission line and the receiver as shown in Figure 1. With input and output impedances of 50 ohms, it is

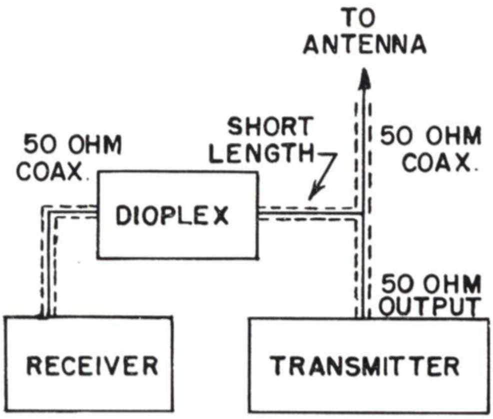


Fig. 1—How the Dioplex is connected

capable of protecting the receiver in accordance with the data in Table II. These figures are RF output—not d-c input. In most cases the allowable d-c input to the transmitter will be slightly higher. How much higher will depend, of course, on the efficiency of the final stage of the transmitter.

It is fortunate that at low frequencies where the receiving insertion loss is greatest, the practical effect on the received signal, though measurable, is still negligible. It is unfortunate, however, that the continuous power rating drops so rapidly with increasing frequency, and that the transmitting insertion loss, while constant, becomes a greater percentage of the permissible transmitter output.

CIRCUIT DETAILS

The complete circuit diagram for the Dioplex is shown in Figure 2. The input goes from a coaxial connector to a plug-in coil. Two biased 6X4 diodes operated back-to-back serve as a voltage-sensitive shunting element. Also, half of one of these tubes is used as a 60-cycle half-wave rectifier to provide diode bias from the transformer. The two selenium rectifiers serve merely as bias voltage stabilizers. The bias will be from 2 to 2.5 volts on each diode. A 3–30 micromicrofarad mica trimmer is used to compensate for variations in the internal tube capacities plus strays. Those interested in a more detailed description of the operation of the Dioplex are referred to the section headed "Thumbnail Theory."

CONSTRUCTION DETAILS

All components of the Dioplex except the transformer are mounted on one of the removable 4 x 5-inch plates of a Bud 3 x 4 x 5-inch utility box. The tube sockets are mounted on an L-shaped bracket that can be simply made of $\frac{1}{16}$-inch aluminum. Before the coil sockets and coaxial connectors are mounted, the paint should be scraped from the plate to assure good grounding. If sockets with built-in by-pass condensers are used (as in the model shown), the by-pass straps should be removed from pin 1 of V_1 and from pin 7 of V_2, since these points operate at RF potential. With ordinary sockets, ceramic by-pass condensers should be installed as close to the socket terminals as possible.

The transformer is mounted in the center of one of the 3 x 5-inch sides of the utility box with the leads from the secondary windings brought inside through a rubber grommet. The primary leads are left free for connection to the 110-volt a-c line. No switch is provided, since accidental damage to the Dioplex and possibly to the receiver can occur if the 6X4 tubes are not energized when transmitting.

Although wiring is not critical, a piece of tinned No. 14 wire is arched between the coil sockets. Keeping this lead in the clear reduces stray capacity and provides an easy method of connecting the plate of V_1, the cathode of V_2, and the "stator" of the mica compression trimmer. The "rotor" of the trimmer is bolted to the L-bracket next to the tube socket as shown so as to provide easy access to the adjusting screw through a $\frac{1}{4}$-inch hole drilled in the top plate. Tinned No. 14 wire also is used to ground the unused pins on the coil sockets, thus providing a measure of shielding.* Insulated wire is used for the other connections.

The high voltage and filament leads from the transformer—connected last—are left their original length and looped around inside the box after the top plate is attached. This makes it easy to remove the top plate should occasion rise.

COIL DATA

All coils are wound on Amphenol polystyrene 5-pin coil forms $\frac{3}{4}$ inch in diameter and $1\frac{5}{8}$ inches long. Two identical coils are required for each band. Winding data is given in Table I. Since none of the windings is more than 1 inch long, the bottom turns can start $\frac{3}{8}$ inch from the base of the forms. In each case, the bottom of the coil winding should connect with pin 3 of the plug-in form and the top of the winding with pin 1—thus providing the widest possible separation at the coil socket. If the winding information is followed closely, it should not be necessary to reset the trimmer condenser when changing bands. The turns should be sealed on the forms with Duco or G-E Glyptal No. 1286 cement. The end turns on each coil should be cemented all the way around the form, and then four strips of cement can be run lengthwise at 90-degree intervals to hold the entire winding in place.

Since polystyrene melts at a relatively low temperature, caution is advised in soldering the coil ends to the pins. The inside of each pin to be soldered should be reamed clean with a drill and a hot iron used just long enough to flow the solder into the pin tips.

* Some eagle-eyed readers may notice that six-hole sockets are used in the model illustrated. This is because they were at hand when this unit was built. The Amphenol 24-5H plug-in forms fit in the six-hole sockets made for the 24-6H coil forms.

GENERAL INFORMATION

It is necessary to assure that a d-c circuit path is

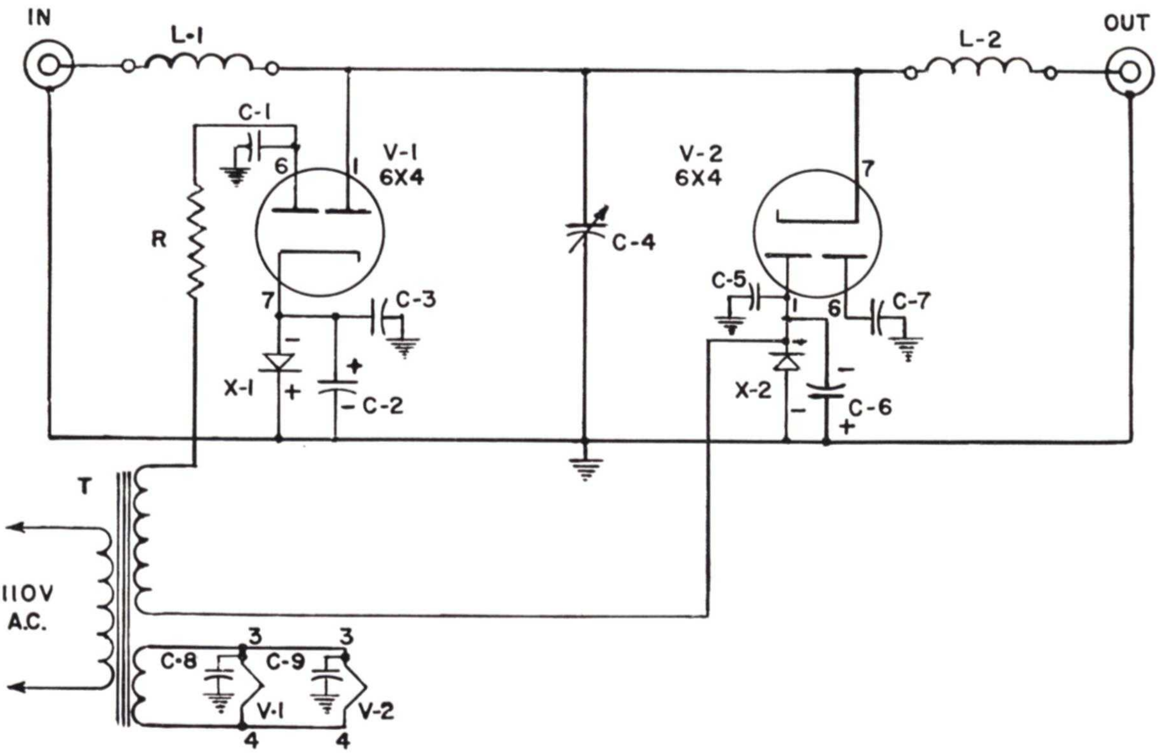


Fig. 2—Circuit diagram of the Dioplex

C_1, C_3, C_5, C_7, C_8, C_9—.001 mfd ceramic bypass
C_2, C_6—50 mfd. 50-volt electrolytic
C_4—3-30 mmf mica compression trimmer
L_1, L_2—(See text and Table I)

R—33,000 ohms, 1 watt
X_1, X_2—100 ma, 380-volt selenium rectifier (GE-5GH1)
T—Power transformer: Pri. 117 V 60 cy; sec. 117 V ½ wave @ 50 ma d-c, 6.3 V @ 2 A (Stancor PA8421)

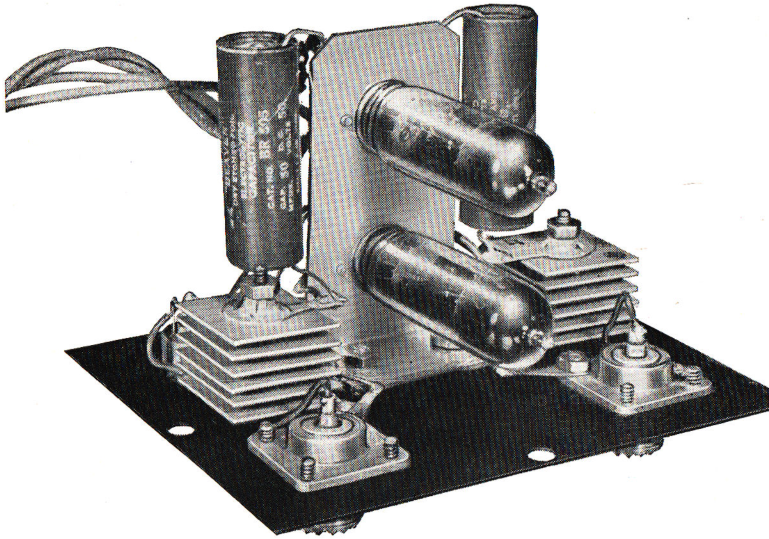


Fig. 3—The 6X4 diodes are mounted on a simple L-bracket

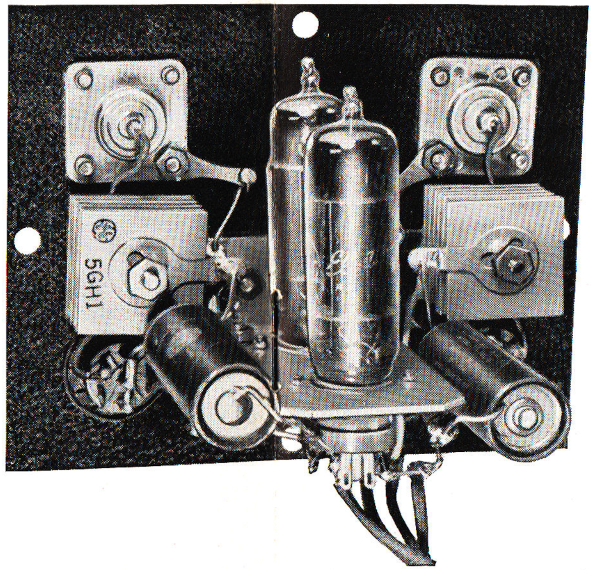


Fig. 4—Components of Dioplex mounted in space-saving arrangement

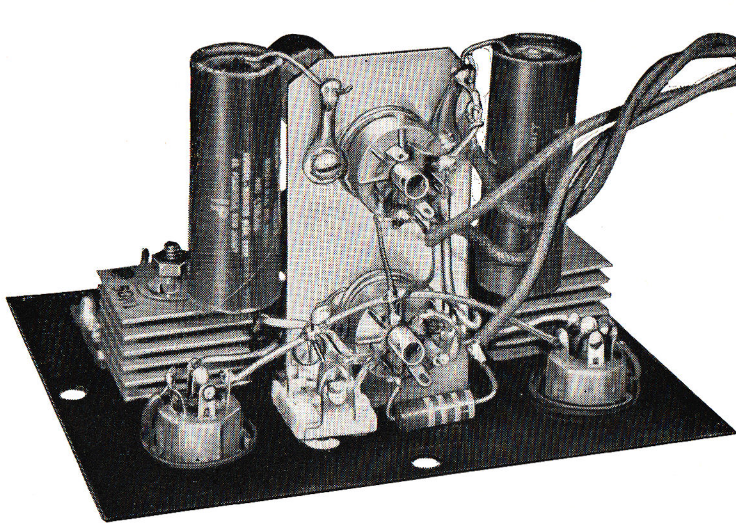


Fig. 5—Tinned No. 14 wire arches over V_1 to connect the two coil sockets

maintained between the coils and the chassis of the Dioplex. Ordinarily, the input coil of the receiver or the output link of the transmitter provides this path through the coax braid. In doubtful cases, this can be checked with an ohmmeter and if no d-c connection exists, a 2.5 millihenry pie-wound RF choke should be placed across one of the coaxial connectors of the Dioplex.

Since the Dioplex design is based on 50-ohm receiver input impedance, deviation from this value will affect principally the amount of power dissipated in the receiver when the transmitter is operating. If there is doubt about the input impedance of the receiver, a 51-ohm 1-watt resistor may be placed across the output connector of the Dioplex to assure that the combination of this artificial load and receiver never exceeds 50 ohms. In most cases, this shunting resistor will not degrade receiver performance.

The power ratings in Table I apply only when the input to the Dioplex—that is, the side that connects to the transmission line—is across a 50-ohm circuit. Simply using 50-ohm coaxial transmission line is not enough to assure that this condition exists unless the standing wave ratio on the transmission line is close to unity. The important consideration here, as far as the Dioplex is concerned, is that the RF voltage applied by the transmitter must not exceed 500 volts at 3.5 mc, 250 volts at 7 mc, 125 volts at 14 mc, 80 volts at 21 mc, and 56 volts at 28 mc. Keeping within these ratings will prevent a receiver from being burned out due to tube failure caused by overload.

The effect of a transmitter connection across the receiver input can be troublesome if the transmitter output stage is not biased beyond cutoff during reception. And with the Dioplex in place, the coupling between transmitter output stage and receiver is very good indeed for low-level extraneous signals sometimes generated in a transmitter that normally is considered "off." Operators of single-sideband stations know that an active output stage coupled to the antenna can cause local receiving difficulties. These difficulties will be greatly magnified with the Dioplex. Blocked-grid

TABLE I—COIL DATA

All coils wound with enamel or Formex insulated wire on ¾-inch plug-in forms (Amphenol 24-5H).

Band	Wire Size	No. of Turns	Length of Winding	Inductance (milli-henries)
3.5	#32	110*	1 in.	0.125
7	#26	57*	1 in.	0.035
14	#19	29*	1 in.	0.00875
21	#19	20**	1 in.	0.004
28	#19	13**	¾ in.	0.0022

* Close-wound. ** Spaced.

CW keying circuits or sufficient protective fixed bias on the output stage of the transmitter should prevent such troubles.

Note the polarities of the electrolytics and selenium rectifiers in the schematic. The cathode of V_1 should be positive with respect to ground, while plate 1 of V_2 should be negative with respect to ground. Thus the polarities indicated on the electrolytic condensers are correct. The selenium rectifiers are connected "backwards" to provide a stiff diode bias source without using much standby power. The GE-5GH1 rectifiers are marked with a red dot on one pole which in this case is connected where the plus signs are marked in the schematic. The d-c voltage across the electrolytic condensers should be checked before using the Dioplex to make certain only about 2 or 3 volts bias appears when the tubes warm up. Much more bias than this indicates either that the selenium rectifier connections should be reversed, or the rectifier is defective.

While in most applications the bias provided will be ample to prevent diode conduction during reception, exceptionally strong incoming signals reaching the Dioplex can cause cross-modulation. If this problem is encountered, two selenium rectifiers can be wired in series where one now is called for in the schematic. The bias then should be from 4 to 6 volts d-c on each 6X4 tube.

One final but important bit of advice. The transmitter never should be operated without the 6X4 tubes in place and the Dioplex energized. The primary of the Dioplex transformer can be connected in parallel with the primary of the filament transformer for the transmitter's output tube or tubes—thus assuring that a major part of the transmitter output will not be dumped into the receiver. Always use the coils for the band on which the transmitter is operating.

INSTALLATION AND OPERATION

As indicated in Figure 1, the lead from the transmission line to the Dioplex should be as short as practical. This connection can be made with one of the coaxial T-connectors, or the Dioplex input can be connected directly on the transmitter output terminals if that method is more convenient. The cable from Dioplex to receiver can be any convenient length. With the transmitter off, the proper Dioplex coils in place and the 6X4 filaments warmed for at least 30 seconds, the mica trimmer should be adjusted for best received signal strength near the high portion of the band. The same adjustment should hold for all bands. The Dioplex can, of course, be peaked for a favorite frequency.

Never attempt to run more than 5000 watts output on CW, AM or NBFM or 10,000 watts peak output on SSB on 80 meters! Similarly, keep within the ratings of Table II on other bands.

THUMBNAIL THEORY

The Dioplex is based on the principle of radar's "T-R box," using lumped circuit constants instead of the transmission lines or waveguides common in radar techniques. A better description might be that the Dioplex is electrically a half-wave filter similar to the Harmoniker (G-E HAM NEWS, Vol. 4, No. 6, Nov.-Dec. 1949). But while best operation of the Harmoniker requires a reasonable impedance match, the Dioplex accomplishes its purpose by means of deliberate mismatch. In fact, the greater the degree of mismatch in this application, the better protection to the receiver.

A half-wave filter such as the Harmoniker effectively is "not in" a circuit of any impedance at the half-wave frequency. In describing the Harmoniker, a curve was given showing how the voltage on the center condenser varied with mismatch. The Dioplex takes advantage of this phenomenon so that a relatively light-duty short-circuiting device across the center condenser can thwart the efforts of a kilowatt rig to get into the receiver through the antenna terminals.

By placing biased diodes back-to-back across the center condenser of the half-wave structure, small signals do not cause conduction in the diodes—and the receiver is connected to the antenna feedline through the half-wave filter. However, when a signal from the transmitter appears across the input to the filter, the diodes become conducting and the receiver is substantially (but not entirely) isolated from the input. At the center condenser, the transmission line voltage is magnified by a factor approximately equal to the ratio of the reactance of one of the coils to the resistance of the load until conduction commences in the diodes. At this voltage, and at any higher input voltage, the magnification ceases and a current flows through the input coil into the diodes which have a net forward resistance of about 400 ohms.

Thus the device becomes a voltage divider of two stages—the first stage being the reactance of the input coil and the diode forward resistance, while the second stage consists of the reactance of the second coil and the input impedance of the receiver. Simply stated, then, the design objectives are: (1) As high a coil reactance as practical, (2) as low a diode forward resistance as possible, and (3) a relatively low load impedance.

These objectives place certain restrictions on the application of the Dioplex, and in effect limit its practical realization to low-impedance receiver input—from 50 to 300 ohms or so—and to operation in a low impedance point in the transmission line feeding the transmitter output to the antenna. This system works out nicely for 50-ohm coaxial circuits, and the design given for the Dioplex is for this application.

TABLE II—PERFORMANCE DATA

Band	Transmitter Output (watts)		Voltage at Receiver*	RF Input to Receiver* (watts)	Insertion Loss*	
	Cont. (Col. 1)	Peak (Col. 2)	(Col. 3)	(Col. 4)	Rec'g (Col. 5)	Xmt'g (watts) (Col. 6)
3.5	5000	10000	1.25	.03	6 DB	10
7	1150	10000	2.2	.1	3 DB	10
14	290	4500	4.5	.4	..**	10
21	130	2000	6.4	.85	..**	10
28	64	1000	8.5	1.45	..**	10

NOTES

Col. 1—Determined by the safe continuous diode current.

Col. 2—Based on maximum safe input voltage, or an average duty cycle of one-quarter (whichever is lower) in the case of single-sideband suppressed carrier operation.

Cols. 3 & 4—Based on continuous CW, AM or NBFM output delivered to a 50-ohm receiver input. The RF power actually delivered to the receiver (Col. 4) will vary in direct proportion with the continuous transmitter output (Col. 1) in each band—*i.e.*, 145 watts continuous output at 14 mc. would deliver .2 watt to receiver.

Col. 5—Based on a coil Q of 100. Coils in unit described have a Q of about 150, so this rating is conservative.

* Approximate.

**Negligible.

SWEEPING *the* SPECTRUM

The other day the editor came back from lunch and upon noting my wrinkled brow and painful "hunt and peck" typing system, he wondered out loud:

"Why should a guy with an electron stream instead of a brain be tied to a typewriter?"

I held my breath and he went on:

"Larry, go on over to the lab and start building something."

"Can't right now," I said. "I've got to write copy for G-E HAM NEWS, read the proof, get pictures taken, arrange for drawings, and—"

"Look, Larry," he said, "I'll do the dull editorial routine. As soon as you finish the column, go plug yourself in and start cooking up something. Concentrate on stepping up your electron stream."

At that I almost popped a filament. It was the best news of the year for me. And soon as I finish here, I'll be heading for the lab.

⁂

The XEs down Mexico way, all het up about their 21st national convention, have been good enough to send a few pictures—including a glamor shot of a pretty, pretty named Alma Velasco, who has been dubbed "Queen of the Hams." The Queen will reign at Guadalajara May 26 through 30. We asked the boss if we ought to run the Queen's picture in G-E HAM NEWS. "No," he said, "the boys are more interested in oscillation than osculation." We pointed out that some of the boys might start oscillating if we ran the picture. But he insisted we need every bit of space for technical dope. So we gently tucked the Queen's picture away in the file.

Some of the items on the program look fascinating. After the opening of XE1N, president of LMRE, we find, for instance: *Planes a Desarrolar Para la Construccion del Edifico de la LMRE* (Ah, new building for the boys); *Defensa de la Patria* (So they have CD too!); *Como se Estudia la Atmosfera con los Globos de Radiosondeo* (How's that again?); *Conferencia Sobre Electronica por un Tecnico de la General Electric* (Good, very good!); *El Porvenir y Desarrollo de la Television* (Oh, oh! Trouble south of the border!).

The boss just poked his head in and said: "Good luck to all the XEs."

⁂

Speaking of national conventions, a bulletin on the 7th National ARRL Convention (Houston, Texas, July 10 through 12) has arrived. It says there are 4230 hotel rooms and motel units in town, and hams who start filling them up early will have a shot at a complete ham station as a pre-registration prize. The program includes VHF, UHF, CD, TV, TVI, ROWH (??), DX, TT, SSB, TFC, EC—and undoubtedly a little XXX in the evenings.

⁂

The boys have been writing like crazy asking for the suggested article on how to determine the noise figure of a receiver. I'm hard at work on it with W2RDL and will pass on the dope as soon as possible . . . Another thing we're working out, with W2KUJ, is a voice control break-in system for SSB . . . By the way, we'd like to hear of experiences with the Dioplex W2KUJ cooked up for this issue . . . and also from those who tried the W2FZW's Mobile/Portable Power Supply and W2KLM's Antenna Loading Coil, both of which were described in the last issue of G-E HAM NEWS . . . We're working with W2RMA on converters for 440 and 220 megacycles . . . and with W2GYV on a new final.

⁂

Just got a note from George Floyd, W2RYT, founding editor of G-E HAM NEWS. He wants to pass 73's to all. George is now working with G-E communications equipment in Syracuse and says he's getting along fine.

⁂

A plea from the hard-working utility and telephone linemen comes via the bulletin of the Detroit Amateur Radio Association, and we pass it along because it can save someone's life—maybe yours. DON'T HANG YOUR SKYWIRE ON A UTILITY OR TELEPHONE POLE!

Three good reasons: (1) Your shack will become an efficient electrocution chamber if wind tosses a conductor of some sort across your wire and the high voltage lines; (2) your RF may light up every circuit on a local LL switchboard; and (3) a lineman may be killed if he trips on your wire while climbing the pole some dark night to restore your phone or power service.

—*Lighthouse Larry*

Technical Information ★ ★ ★ ★ ★ 6005

THE RUGGEDIZED 6AQ5

The GL-6005 is one of G.E.'s line of 5-Star high reliability tubes which are specially designed to assure dependable life and reliable service under the exacting conditions encountered in mobile work.

Features include mechanical ruggedization and heater-cathode construction designed to withstand many-thousand cycles of intermittent operation. Electrical characteristics and pin connections are identical with the 6AQ5—the beam power pentode popular in small rigs and receivers.

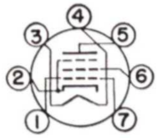
The tube is described here merely as a matter of general information, inasmuch as few hams require such exacting performance. However, those interested can get full details from bulletin ETX-265.

SPECIAL CHARACTERISTICS

Peak Impact Acceleration in Any Direction* . . 600 G
Vibrational Acceleration in Any Direction† . . 2.5 G

* Forces in any direction as applied by the Navy Type High Impact (flyweight) Shock Machine for Electronic Devices or its equivalent.

† Vibrational forces in any direction for a period exceeding 100 hours at a frequency of 60 cps.



TYPICAL OPERATION

CLASS A_1 AMPLIFIER

Plate Voltage	180	250 Volts
Screen Voltage	180	250 Volts
Grid Number 1 Voltage	−8.5	−12.5 Volts
Peak A-F Grid #1 Voltage	8.5	12.5 Volts
Plate Resistance (Approx)	58000	52000 Ohms
Transconductance	3700	4100 Mho
Zero-Signal Plate Current	29	45 Ma
Maximum-Signal Plate Current	30	47 Ma
Zero-Signal Screen Current	3	4.5 Ma
Maximum-Signal Screen Current	4	7 Ma
Load Resistance	5500	5000 Ohms
Harmonic Distortion (Approx)	8	8 %
Power Output	2.0	4.5 Watts

CLASS AB_1 (VALUES FOR TWO TUBES)

Plate Voltage	250 Volts
Screen Voltage	250 Volts
Grid Number 1 Voltage	−15 Volts
Peak A-F Grid-to-Grid Voltage	30 Volts
Plate Resistance (Each Tube)	60000 Ohms
Transconductance (Each Tube)	3750 Mho
Zero-Signal Plate Current	70 Ma
Maximum-Signal Plate Current	79 Ma
Zero-Signal Screen Current	5 Ma
Maximum-Signal Screen Current	13 Ma
Effective Load Resistance (P-to-P)	10000 Ohms
Total Harmonic Distortion	5 %
Maximum-Signal Power Output	10 Watts

G-E Electronic TUBES

Ham News

Available FREE from
G-E Electronic Tube Distributors

A Bi-monthly Publication
TUBE DEPARTMENT
GENERAL ELECTRIC
Schenectady 5, N. Y.
(In Canada, Canadian General Electric Company, Ltd., Toronto, Ont.)

Printed in U.S.A.

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