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ECONOMY HALF-KILOWATT

Two Tube, Two Band Rig Designed for Traffic Handling

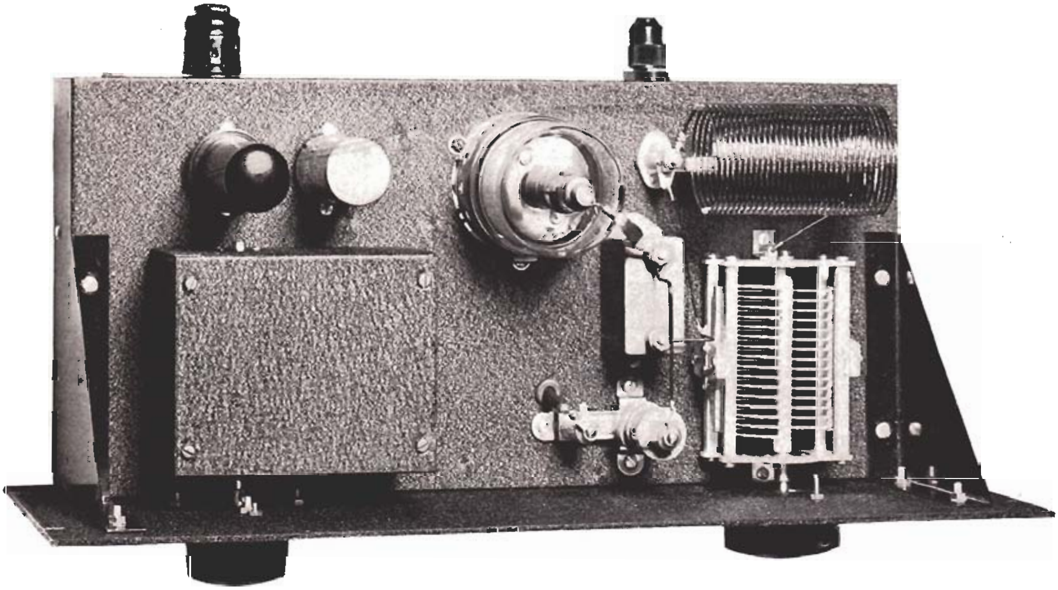

Fig. 1. Top View of Economy Half-Kilowatt. Note Extreme Simplicity.

This c-w man's rig, shown in Fig. 1 from a top view, features a self-contained VFO, simplicity, compactness, two-band operation, and sufficient power for almost any job. A General Electric GL-1614 serves as the variable-frequency oscillator. The grid circuit of the oscillator operates on the 80 meter band, and the plate circuit either works straight through or doubles in order to drive the GL-4D21/4-125A final. In order to change from 80 meters to 40 meters or vice versa it is necessary only to change two coils. The final is capable of an input of 500 watts.

DESIGN OBJECTIVES

A large percentage of the active amateurs are actively engaged in traffic handling. Despite this, very few transmitters are ever designed with their requirements in mind. The Economy Half-Kilowatt design has as its objective Reliability, Flexibility, Conservative Circuit Design and Economy.

Reliability dictates the use of moderate power. Any power between three hundred and five hundred watts meets this requirement. The Economy Half-Kilowatt can loaf along at 400 watts input, or be pushed up to its maximum rating of 500 watts.

Flexibility demands a self-contained VFO of good stability, break-in keying, and a minimum number of controls. Conservative circuit design is necessary so that the rig will be able to operate for hours on end without breakdowns of any sort. Economy goes hand-in-hand with most of the other objectives. Fancy frills add to the cost of a transmitter, but traffic handling does not seem to require these extras.

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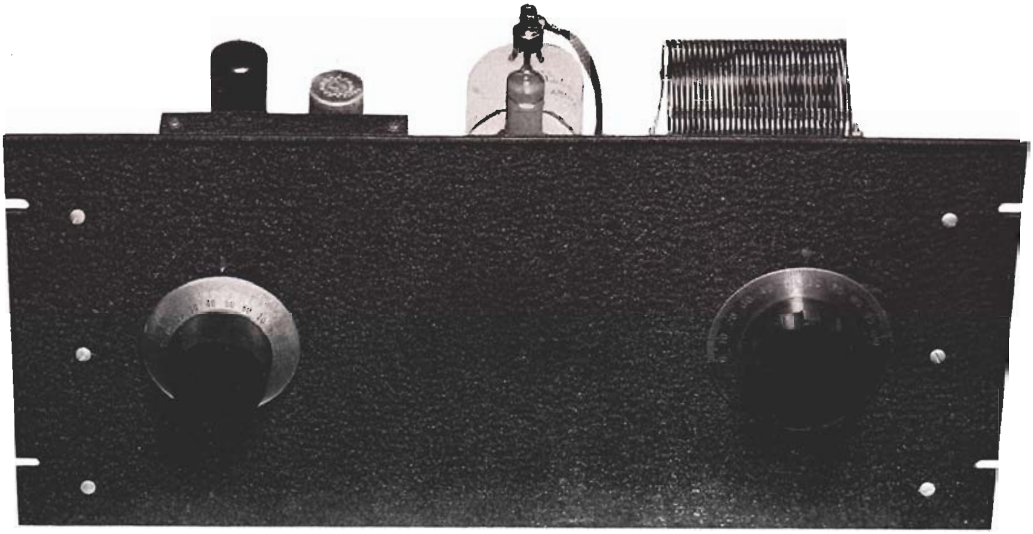

Fig. 2. Front View of Economy Half-Kilowatt. Oscillator Tuning on the Left.

DESIGN DETAILS

Good design requires that the output stage be selected and designed first, then the transmitter designed backwards from that point. Starting with the output stage, there are many tubes that might be selected in order to run the desired three hundred to five hundred watts input. From a standpoint of simplicity and high power gain, a single power tetrode is highly desirable. In order to achieve high power gain some precautions must be observed in mechanical layout, shielding and bypassing. The effort involved in accomplishing this is small when one considers that the driving stage (or stages) becomes very simple. Further, it is possible to employ, practically, broad-band interstage coupling when a high power gain final is used.

Which tetrode shall we select? Assuming that the builder takes reasonable precaution against accidental coupling of the grid and plate tuned circuits, then the principal type of parasitic oscillations that can occur must be of the tuned-plate tuned-grid variety. The ease with which these particular parasitics may be started is determined to a great extent by the grid-plate capacitance of the final tube. Therefore, in order to minimize the possibility of TPTG oscillations occurring, it is wise to select the tetrode with the lowest grid-plate capacitance. It is for this reason that the GL-4D21/4-125A was chosen.

It is certainly desirable to be able to have a broad-tuned output circuit, that is, one which does not require retuning from one end of the band to the other. However, this is nearly impossible unless a specific antenna of *known* characteristics is considered. For this reason the output tank circuit is conventional, and arrangements are made to tune the final from the front panel. An operating Q of 12 was used in designing the coils and choosing the capacitor. This is a practical compromise figure considering both harmonic radiation and circuit efficiency.

Having decided upon the final stage design, the driver stage is next under consideration. Probably the simplest driving stage is a straight ECO using a tube capable of moderate power output. Most amateurs tend to avoid this type of thing because it has become common practise to use one or more buffer stages in an effort to achieve stability in the VFO. However, this practise is definitely not necessary if care is taken to see that the VFO is properly loaded (See Technical Tidbits, Ham News, July-August 1948, page 4).

A non-inductive resistor placed across the plate circuit of the oscillator can be made to load the oscillator properly as well as broaden the tuning of that circuit so that a fixed tuned circuit may be used, thus eliminating a tuning control. The complete circuit diagram of the Economy Half-Kilowatt is shown in Fig. 4.

CIRCUIT DETAILS—OSCILLATOR

The problem of stability in the oscillator can be approached several ways. The simplest approach is to try to isolate the tube from the frequency determining circuit as much as possible consistent with moderately strong oscillations. This has been discussed recently in Proceedings of the I. R. E., QST and CQ magazines.

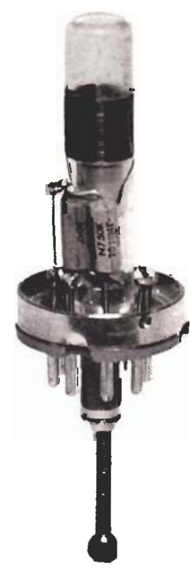

Fig. 3. Detail View of Oscillator Plate Coil.

The oscillator shown in Fig. 4 is one of a group of similar principle which have been under test in various ham shacks, principally that of W2FZW, since mid-1947. The results of these tests has been to show that crystal-like stability can be obtained with a minimum of construction effort and adjustment difficulty. The circuit as shown required absolutely no adjustment other than setting the band limits with the band-set condenser.

Further, the isolating properties of this type of circuit were sufficiently good so that it was possible to use a **GL-1614 tube as** the oscillator in order to obtain a moderate output. This particular type of tube is not extremely well shielded and for this reason is not normally used in the conventional ECO circuit.

Since the Q of the grid tank (L_1) as well as the fixed capacitance determines how well the isolation attainable in this class of oscillators can be achieved,

ELECTRICAL CIRCUIT

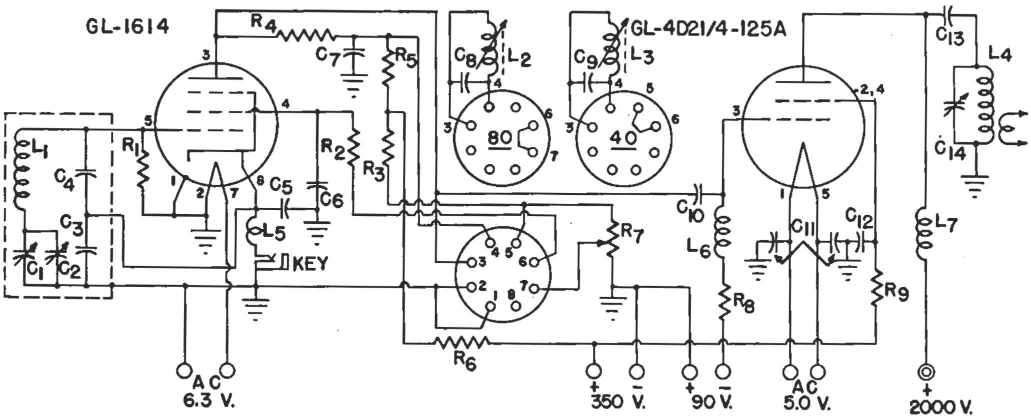

Fig. 4. Circuit Diagram of the Economy Half-Kilowatt.

CIRCUIT CONSTANTS

C_1	= 75 mmf variable (Hammarlund APC-75)
C_2	= Approx. 15 mmf variable, see text
C_3, C_4	= 500 mmf mica
C_5	= 250 mmf mica
C_6, C_{12}	= 0.002 mf 600 volt mica
C_7	= 0.005 mf 600 volt mica
C_8	= 75 mmf ceramic (50 mmf and 25 mmf in parallel)
C_9	= 25 mmf ceramic
C_{10}	= 100 mmf mica
C_{11}	= 0.01 mf mica
C_{13}	= 0.005 mf 3000 volt (working voltage)
C_{14}	= 150 mmf variable (Hammarlund MTC-150-B)
L_1	= 64 T, one inch diameter, two inches long (B & W Miniductor #3016)
L_2	= 40 T, #30 enamel wire, close wound on ½ inch slug-tuned plug-in form (Millen #74001)

L_3	= 20 T, same as L_2
L_4	= 80 meters: 32 T, #14 wire, space wound 8 T per inch on two inch diameter 40 meters: 24 T, #14 wire, space wound 6 T per inch on two inch diameter
L_5, L_6	= 2.5 millihenry RF choke (Millen #34100)
L_7	= 1 millihenry, 600 mil RF choke (National R-154)
R_1	= 0.1 meg ½ watt
R_2, R_5, R_8, R_9	= 100 ohm ½ watt
R_3	= 3900 ohm 1 watt
R_4	= 10,000 ohm, 10 watt, *non-inductive* (Sprague Koolohm 10NI, 10W, 10,000 ohm)
R_6	= 150 ohm 1 watt
R_7	= 25,000 ohm, 25 watt, semi-adjustable

it is strongly recommended that the specifications here be followed *exactly.* While other components will work, few amateurs have the test equipment to check substitutes and so avoid trouble. With this in mind only moderate cost, readily available parts are specified. L_1 consists of a Barker and Williamson Miniductor (#3016) which is cut to a length of two inches (see Fig. 6).

The main tuning condenser for the oscillator grid, C_2, is a Hammarlund MC-20-SX (or MC-35-SX) which has had plates removed so that only two rotor and three stator plates remain. The approximate net capacitance is then 15 mmf. Using this capacitance gives a good amount of bandspread, so that 3.5 to 3.85 megacycles covers almost 180 degrees and 7.0 to 7.3 megacycles covers approximately 75 degrees. Condenser C_1 is the band-set condenser which is adjusted so that C_2 covers the proper part of the band.

It is important to follow the circuit details of the plate circuit exactly if proper results are to be achieved. Particularly important is R_4 which is the loading resistor for the plate tank. This is a non-inductive resistor. The Sprague NI or NIT Kool ohm series is satisfactory in the 10,000 ohm, 10 watt size. Be certain that this resistor is not a KT type, as this latter type is not non-inductive.

Resistors R_2 and R_5 are placed in the circuit for convenience in taking current measurements. A milliammeter may be connected across R_2 to read screen current to the GL-1614, and similarly a meter across R_5 will read plate current to the oscillator. Jacks could be substituted for resistors at these points. Resistors R_3 and R_7 form the screen bleeder.

The plate coils are wound on Millen #74001 permeability tuned plug-in coil forms. Padding condensers for each plate tank are wired directly across the coils inside the coil shield (see Fig. 3). The use of these octal plug-in forms permits screen voltage change when going from 80 to 40 meters. The GL-1614 is designed to have an output, when doubling, of twice that required to drive the GL-4D21/4-125A final. One-half of this power, approximately, is absorbed by the loading resistor R_4. When the oscillator tube is working straight through an excess of power is available. In order to cut this power down to the proper amount, the screen voltage is dropped from its 250 volt value down to less than 200 volts. This is done by changing the connection on pin 6 of the plate coil socket over to pin 7. This change is automatically made when coils are changed. The net effect of this change is to cause the screen voltage to be picked off the tap on R_7 rather than off the top of R_7. The adjustment of the position of this tap will be discussed later.

Condenser C_5 is not a cathode bypass condenser but is actually a part of the cathode-to-ground

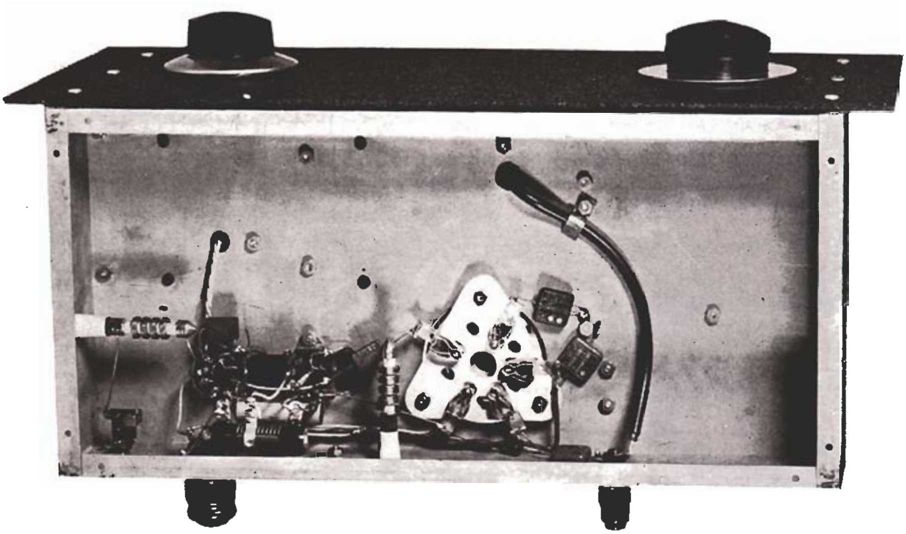

Fig. 5. Under-chassis View of Economy Half-Kilowatt.

capacitance of the grid tank. It is shown separately because it was found desirable to be added later and it is located under the main chassis rather than in the oscillator shielded box. Proper results will be obtained with C_5 either as shown or with it inside the oscillator shield box.

CIRCUIT DETAILS—FINAL

The grid circuit of the final is fed through condenser C_{10}. An untuned grid circuit of usual design is employed. Resistor R_8 is included for convenience in measuring grid current. It could be replaced with a closed-circuit jack if desired. The r-f choke, L_6, is not critical, and most 2.5 millihenry chokes should work satisfactorily.

Resistor R_6 acts as a decoupling resistor between the oscillator circuit and the final screen grid circuit. R_9 is used for measuring the screen current to the final tube.

The final tank circuit employs shunt feed in the interest of safety. This permits the final tank condenser to be grounded, and no d-c voltage is present on this condenser. The r-f choke, L_7, is specified as a National R-154 choke. It is recommended that no substitution be made at this point. Of a large group tested, this particular choke was quite satisfactory, while others would have burnt up if used. The choke is critical partially because it is being used in a shunt feed circuit.

MECHANICAL DETAILS

The Economy Half-Kilowatt is built on a 17 x 8 x 3 inch chassis on which is mounted the 8¾ inch x 19 inch relay rack panel. The top and underside views, Figs. 1 and 5 show that despite the small size of the unit, there is no evidence of overcrowding. The extreme simplicity of controls is indicated in Fig. 2 which shows that only two controls are brought out to the front panel. Oscillator tuning is on the left and final plate tank tuning is on the right. Each control is centered four inches in from each side and is 4¼ inches down from the top of the panel.

In Fig. 1 will be seen the oscillator grid circuit shielded box, which is a standard 3 x 4 x 5 inch metal box. All components in the circuit diagram contained inside the dotted lines are placed in this shielded compartment. Directly behind the compartment are the GL-1614 oscillator tube and the oscillator plate tank plug-in coil.

The shielded compartment is located three-fourths of an inch back from the front panel and one and a half inches from the left side of the chassis. A detail view inside this shield box is shown in Fig. 6. The grid coil, described previously, is cemented to a piece of polystyrene 2¾ inches long and ¼ inch wide. This support piece is drilled on the ends and is mounted on two half-inch long spacers which fasten through the shield box to the chassis beneath.

Condenser C_2 is mounted directly on the shield box and the shaft then extends far enough so that it connects to the National Velvet Vernier dial on the front panel. Condenser C_1 similarly mounts on the shield box directly behind C_2. Tuning of C_1 is done from the rear. Fixed condensers C_3 and C_4 are strapped together and fastened to the bottom of the shield box as shown in Fig. 6. It is extremely important that all components inside this box be rigidly fastened down so that they are unable to move. Wiring should be done with heavy solid wire.

Fig. 5 shows the remainder of the oscillator circuit wired under the main chassis. The keying jack may be seen in the corner of the chassis. An octal socket and plug are mounted on the rear of the chassis to bring in filament voltages and plate voltage for the oscillator and final screen. Filament voltage for the final is wired to four of the pins, with two pins being in parallel for each lead. This is done so that the relatively heavy current (6.5 amperes) does not cause any appreciable voltage drop. The other four pins are used for bias, plus 350 volts, 6.3 volts, and ground.

A detail view of the oscillator plug-in coil, with shield removed, is shown in Fig. 3. The 80 meter coil is the one pictured. Pin 1 of these coil forms is connected to the base shell of the unit by a jumper wire, and pin 2 is soldered to the metal portion of the screw assembly directly in the center of the base of the form. These two connections are not indicated on the circuit diagram of the two coils. The purpose of these connections is to thoroughly ground the form.

The GL-4D21/4-125A tube socket is mounted underneath the chassis, with only the shell grounding clips being above chassis. A 2¾ inch hole is made in the chassis on a center which is two inches from the rear of the chassis and eight inches from the right hand side of the chassis. The use of a National HX-100 socket is recommended as this type furnishes the clips which contact the base shell of the GL-4D21/4-125A tube.

The location of the tuning condenser, C_{14}, final tank coil, L_4, r-f choke L_7 and blocking condenser C_{13} is seen in Fig. 1. There is ample room in the center of the panel for a meter to read plate current, if desired. It was omitted in the interest of economy. The high voltage lead which comes up through the chassis and connects to the r-f choke could be connected instead to a meter, with the other meter lead going to the r-f choke. If a meter were to be used there which read several currents, such as grid current and oscillator plate current, care would have to be taken to see that undesired feedback was eliminated. The layout of the transmitter has been arranged to avoid feedback. Note in Fig. 5 how the high voltage lead which comes from the Millen high voltage terminal on the rear carefully avoids running near any other part of the circuit.

The final tank coil pictured in Fig. 1 is a home-made unit. The wire is wound over and cemented to strips of polystyrene. An extra strip of poly (4⅝ x ⅜ x ⅛ inches) is cemented on the bottom of the coil and is drilled to pass 6-32 screws. This allows banana jacks to be fastened to the coil, permitting it to be plugged into the insulators which act to support the coil from the chassis. The insulators are spaced for a mounting distance of 4¼ inches.

OTHER BAND OPERATION

Because of the fundamentally simple design of the Economy Half-Kilowatt, operation on other bands is not feasible unless a great deal of redesign work is done. For example, for operation on the 20 meter band, it would be necessary to quadruple in the oscillator. There might be enough drive for the final, but only if the voltage were raised on the oscillator tube. This would bring about complications, probably necessitating the changing of resistors R_3, R_4 and R_7.

Perhaps an easier method would be to redesign the oscillator stage so that it operated on 7 megacycles instead of 3.5 megacycles. In this case L_1, C_1, C_2, C_3 and C_4 would probably have to be changed in value. A further point is that for operation on other than 3.5 and 7 megacycles the r-f choke in the final, L_7, would have to be carefully checked to insure that it had sufficient impedance on the 20 meter band to act as a shunt choke.

TUNE-UP PROCEDURE

The first step is to insert the 40 meter coils in the plate circuit of the oscillator and the final. Energize the filaments of both tubes, apply bias voltage to the final, and disconnect R_9 from the screen of the final. This is done so that screen voltage will not be applied to the final tube when no plate voltage is present. Next, apply 350 volts to the oscillator. Set C_2 so that the plates are approximately two-thirds meshed. Then, listening on a receiver which is calibrated, set C_1 until the frequency generated by the oscillator is approximately 3.5 megacycles. With the 40 meter plate coil in place (L_3), read grid current to the final. With no voltage on the final this current will be in the order of 15 mils. This current should be maximized by tuning the slug in coil L_3 after the frequency has been shifted to approximately 3.68 megacycles (midway on the oscillator tuning dial).

The next step is to put screen and plate voltage on the final. Reconnect R_9 and connect the high voltage to the high voltage terminal. The final should be tuned to resonance and loaded, preferable with a dummy load, until it draws approximately 190 to 200 mils. Note the grid current to the final under these conditions.

The coils should now be changed to the 80 meter

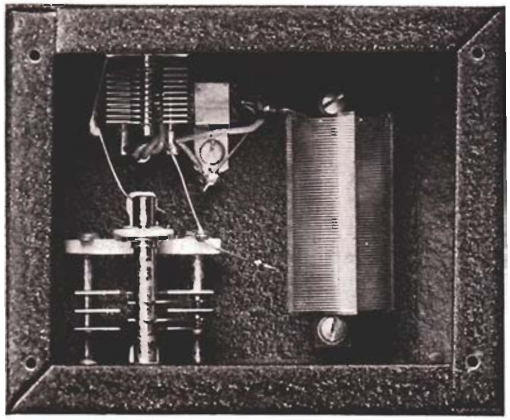

Fig. 6. Detail View of Oscillator Grid Circuit.

coils. With the final again loaded to the same point, note the final grid current after peaking L_2. It is now necessary to adjust R_7 (plate voltages should be removed while this adjustment is being made) until the grid current to the final is the same on 80 meters as it was on 40 meters. Adjustment of R_7 has no effect on the grid current on 40 meters but has control only of the grid current on 80 meters, as R_7 adjusts the screen voltage to the oscillator only when the 80 meter oscillator plate coil is in place. Loaded final grid current will run about 10 mils.

Once these adjustments are complete, it is desirable to check the calibration of the oscillator tuning dial to insure that it covers the band. A check of the final grid current should also be made to be certain that the drive is holding constant over the entire band. The check should be made on both the 80 and 40 meter bands.

When doubling, the oscillator plate and screen currents should be approximately 48 mils and 2.5 mils, respectively. For straight-through operation, these currents will run about 25 mils and 1.5 to 2 mils.

No antenna coil link is shown on the final plate coil. The size of the link is determined to a great extent by the antenna and feeder line used. The link may be made of well-insulated wire wrapped around the coil until the exact type of link is determined, then a better link may be made up and used. Enamel wire cemented to polystyrene strips on a diameter to slide over the main coil will serve very nicely.

PERFORMANCE

The stability of the completed oscillator was entirely sufficient for all practical uses without temperature compensation, and so none is indicated. Those amateurs who have to live with a fluctuating ambient temperature or who enjoy achieving the ultimate in precision may experiment with a small negative coefficient capacitance across the main padding condenser C_1.

The keying characteristics and stability of the oscillator is better than a large number of crystal oscillators against which it has been compared.

Parasitic-wise the Economy Half-Kilowatt is a beautiful performer. For example, the transmitter pictured, which has no parasitic suppressors of any sort, had 1000 volts applied to the plate circuit. The bias was reduced so that the plate current was 125 mils. Under these conditions no trace of oscillation could be detected at any setting of the plate tank condenser with any combination of coils in place. Many so-called neutralized rigs will not pass this sort of test.

TECHNICAL TIDBITS

PROPER PLATE TANK PADDING

There comes a time when practically every ham wants to take a high-frequency rig and by hook or crook, make it work on a lower frequency. This involves wiring around frequency multiplier stages and winding new coils. It also involves worrying about the fact that the tuning condensers are of too low a capacitance to meet the requirements for a proper Q. The usual reaction to this problem is to parallel the old condensers with fixed capacitance of some sort, vacuum capacitors, discarded tuning condensers or anything which will add the proper capacitance.

Unless proper procedures are followed in this padding stunt, it is very likely that a nice case of TVI will be developed, or perhaps a polite note from the FCC regarding harmonic emission. There is a right and a wrong way to add padding capacitance across a tuned circuit.

If the circuit considered is a single tube circuit with a single-ended plate tank, that is, one which has a single-section tuning condenser and a coil where the B plus voltage feeds in at the bottom, then no further worrying need be done. Padding capacitance may be added directly across the tuning condenser and the circuit will not be changed effectively by the added capacitance.

However, if the circuit is a single tube circuit with a double-ended plate tank, which is needed if the tube is neutralized, or if the circuit is a push-pull circuit, where again a double-ended plate tank is used, then we must watch out for gremlins. These gremlins take the shape of undesired harmonic signal output. Second harmonic, third harmonic and other harmonic signals will be present in the plate tank coil and thus be radiated if we allow these various harmonic currents to flow through the coil and induce their own voltages in the coil. To minimize the possibility of radiating these harmonics, it is necessary only to keep these harmonic currents from flowing through the final tank coil.

With reference to Fig. 7A, this circuit is one which is commonly used with either a single tube or a push-pull stage. C_1 is the tuning condenser and C_X the usual bypass condenser. When this circuit is tuned to resonance, it will have a very high impedance to current which comes from the tube and which is an r-f current at the fundamental frequency. However, current is also coming from the tube at radio frequencies which are harmonics of the fundamental frequency. These harmonic currents do not see the tank circuit as a resonant tank, but they merely see the tank circuit as a combination of inductance and capacitance, the inductance acting as a choke and the capacitance acting as a bypass condenser. These harmonic currents, like the fundamental current, are trying to find a path to ground. Naturally they will take the lowest impedance path. In Fig. 7A the only path for these harmonic currents is the path through the coil proper, through condenser C_X, and thence to ground.

If one tube is considered, then the path is through the top of the coil, whereas with a push-pull circuit, one tube sends its currents through the top of the coil and the other tube through the bottom of the coil. In any case, these harmonic currents are passing through the coil, and therefore they induce a harmonic voltage in the coil. Further, as higher and higher harmonics are considered the coil becomes a better and better choke, therefore the higher and higher a harmonic voltage will be induced. This means that the antenna link will pick up these voltages, send them on to the antenna, which will radiate these harmonics. Of course, many stunts are used in order to prevent the harmonic voltage from being coupled to the antenna, but we are interested here in preventing the harmonic voltage from existing.

How is this done? Refer to Fig. 7B. This is identical to Fig. 7A except that C_1 has been replaced with a split-stator condenser C_2. Now, when harmonic currents come from the tube, they are faced with the problem of whether to go through the coil (with its increasingly high impedance to higher and higher frequency harmonics), or whether to go through the split-stator condenser, C_2, (whose impedance is decreasing with frequency and which is becoming more and more effective as a bypass condenser as higher order harmonics are considered). Because of the difference in the impedance of these two paths, most of the harmonic current will take the path through C_2.

Before we start praising this circuit too greatly, however, let us examine it more closely. The two halves of the coil are coupled together and the center-tap is rather firmly tied to ground through condenser C_Y. If these two halves of the coil are overcoupled, as is usually the case, then the resonant curve for the entire coil may turn out to have a double hump. This is a nasty situation because it is then impossible to tune C_2 properly. If C_2 is set for the resonant frequency, then the impedance of the coil is not what it should be, and if C_2 is tuned so that the impedance is correct, then the circuit is not exactly at resonance.

This situation may be avoided by a few quick twists of a soldering iron, so that the circuit resembles that in Fig 7C. Another equally correct circuit would be with C_Z omitted and the center of C_3 grounded, with the r-f choke disconnected from the center of C_3, or any combination of the above. The important thing is to omit the bypass condenser which you

(Cont'd on page 8)

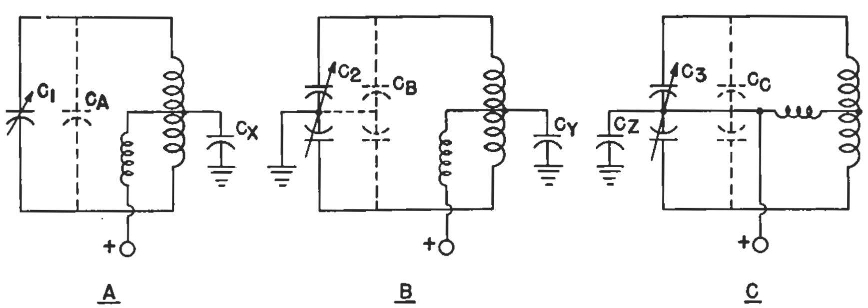

Fig. 7. Double-Ended Output Tank Circuits Discussed Above.

QUESTIONS AND ANSWERS

Do you have any questions about tubes or tube circuits that are of general interest? For each question published you will receive $10 worth of G-E Electronic Tubes. Mark your letter "Entry for Questions and Answers" and send to Lighthouse Larry, Tube Division, Bldg. 269, General Electric Company, Schenectady, New York, or in Canada, to Canadian General Electric Company, Ltd., Toronto, Ontario.

DRIVING POWER

Question: Does it take more power to drive a class C amplifier with resistor bias than with fixed bias?
—W3IZR.

Answer: For any one operating condition the peak grid voltage swing must be the same regardless of how the bias is obtained. The driving power required is the peak grid voltage swing multiplied by a figure called average product of sine amperes. This latter figure is unaffected by the grid bias method. Therefore if the average d-c grid current is the same, then the same amount of driving power will be required whether bias is obtained from a resistor, a battery, cathode bias, or any other means.
—Lighthouse Larry.

RECEIVER TUBE TESTING

Question: Sometimes a tube will test good in a tube tester and yet will not oscillate when used as an oscillator tube in a superheterodyne receiver. What should be done so that the circuit will oscillate with average tubes?—S. J. Manson.

Answer: If a good tube will not oscillate when used in a commercial (not home-made) receiver, it is very probable that the tube is bad from a mutual conductance standpoint. This type of thing would not be noticed on a regular tube tester as most testers check the tubes for emission only. A tube can have good emission and yet have a low mutual conductance.

Most commercial receivers are tested at the factory with oscillator tubes which have as low a mutual conductance as is permissible by the tube specifications. These tests are also made with low line voltage on the receiver. This means that regardless of the tube used, a replacement tube should oscillate.

Considering home-made receivers, the circuit is probably at fault if the oscillator tube will not oscillate, assuming that the tube is good.—Lighthouse Larry.

TRICKS AND TOPICS

How did you solve that last problem that almost had you stumped? Be it about tubes, antennas, circuits, etc., Lighthouse Larry would like to tell the rest of the hams about it. Send it in! For each "trick" published you win $10 worth of G-E Electronic Tubes. No entries returned. Mark your letter "Entry for Tricks and Topics" and send to Lighthouse Larry, Tube Division, Bldg. 269, General Electric Company, Schenectady, New York, or in Canada to Canadian General Electric Company, Ltd., Toronto, Ontario.

VARIABLE CONDENSER

Several types of air trimmer condensers are now on the surplus market at very low prices. Their main disadvantage is that most of them do not have a shaft, but have a screwdriver slot cut in a short hexagonal hub. A shaft can easily be added. (See Fig. 8).

Procure a fiber hex wrench to fit the hexagonal hub and cut a one-half inch piece from this wrench. Slip this over the hex hub on the condenser so that it is a tight fit. Put a couple of drops of poly coil dope in the opening and then insert a length of one-fourth inch poly rod. When the coil dope has hardened you will have a shaft almost as strong as a metal one.—R. S. Brown.

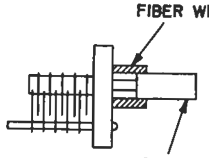

Fig. 8. Hex Shaft Variable With Regular Shaft Added.

CRYSTAL STRETCHING

A crystal is basically a single frequency device, but many times it is handy to be able to move a little to one side or another in order to avoid QRM. Also, those of you who grind your own crystals may have found on occasion that your last efforts have pushed the frequency a little too high.

There are many ways to change the frequency of a crystal. These include a light application of pencil marks on the crystal surface, India ink on the crystal, and placing cigarette papers between the crystal and its electrodes.

I found that these stunts did not always work too well with the small surplus crystals that plug into an octal socket. The best method I've found that seems to work with all crystals is to reverse the hollow ground electrode plates so that the flat side is next to the crystal. For example, reversing both electrodes of a 7 megacycle crystal reduces the frequency by almost two kilocycles, while reversing one electrode reduces the frequency about half of that amount. There is no apparent effect on stability or activity.—W7JFV/KL7.

NON-SLIP EQUIPMENT

Small compact test instruments are a popular tool around any ham shack or shop. From experience I've found that the exterior surfaces of these instruments are usually made with a very slick surface. This may result in slippage when the unit is accidently pulled by the leads. In my case it resulted in the breakage of the whole unit.

One way to stop this is to sand the bottom surface, give it a coat of rubber cement, and then apply a thickness of sponge rubber padding. The unit will then stay put and even when pulled by the leads it will give a strong warning before colliding with the floor.
—W3ITL/KL7.

occasionally find tied to the center of the tank coil. The introduction of the r-f choke in the center-tap lead of the coil in Fig. 7C and the omission of the bypass condenser at the center-tap point practically guarantees that all of the harmonic current will flow through C_3 to ground.

Now what about this padding that we started to discuss early in this article? In Fig. 7A, a padding condenser (C_A) would normally be added directly across C_1. Inasmuch as this circuit is already beyond hope, we are adding the last coffin nail by so doing. Ergo, don't add C_A as shown. If you insist on using that circuit, the least that can be done is to add two padding condensers in series across C_1. Then, if the junction of these two padding condensers is tied directly to ground, or bypassed to ground, we have minimized harmonic radiation by providing a low impedance path to ground. Also, with these series padders in place, we can remove C_X and store it in the junk box. Now that that has been done, note that this circuit is now a brother of the circuit in Fig. 7C.

Fig. 7B is a circuit that it is best to stay away from, but if it were to be used, two padding condensers should be used, at C_B, one each across the two sections of the tuning condenser C_2. If at this point you can talk yourself into removing the bypass condenser, C_Y, you will have made this circuit into another brother of the one in Fig. 7C. Referring to this latter circuit, padding capacitance should be added as indicated at C_C. If a single padding condenser were added directly across the whole tank coil then the harmonic currents could get to ground only through the original split-stator condenser C_3, which is now extremely small in capacitance compared to the rest of the circuit, and hence rather ineffectual. The current would divide, some going through this condenser, and the rest through the coil. This division of current would depend on the exact values of the capacitance and the inductance, but the point is that much current would be passing through the tank coil, and therefore producing harmonic voltages, which need not pass through if the padding capacitance were also made up in a split-stator arrangement.

Summing up all of the above, make sure that you have the proper circuit to start with. Then, when you add padding capacitance to this circuit to reach a lower frequency, make sure that you parallel both sections of the split-stator condenser with individual padding condensers. Your reward will be an improvement in tube efficiency and a silent muttered prayer from your neighbors.—Lighthouse Larry.

TECHNICAL INFORMATION
GL-4D21/4-125A

DESCRIPTION

The GL-4D21/4-125A is a four-electrode tube designed for use as a power amplifier and oscillator. The anode is capable of dissipating 125 watts, and cooling is accomplished by radiation. The cathode is a thoriated-tungsten filament. Maximum ratings apply up to 120 megacycles.

GENERAL CHARACTERISTICS

Number of electrodes	4	
Electrical		
Filament voltage	5.0	volts
Filament current	6.5	amperes
Grid-screen amplification factor	6.2	
Interelectrode capacitances		
Grid No. 1 to plate*	0.05	micromicrofarad
Input	10.8	micromicrofarads
Output	3.1	micromicrofarads
Transconductance, $I_b = 50$ ma, $E_b = 2500$ v, $E_c2 = 400$v	2450	micromhos

*Without external shielding, base shell connected to ground.

Electronics Department

GENERAL ELECTRIC

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