ECONOMY HALF-KILOWATT
Two Tube, Two Band Rig Designed for Traffic Handling

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

This cw 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-1814 serves as the variable-frequency oscillator. The grid circuit of the oscillator operates on the 80 meters band, and the plate circuit either works straight through or doubles in series to drive the GL-4202/1-125A 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 output 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 ablates the use of moderate power. Any power between three hundred and five hundred watts meets this requirement. The Economy Half-Kilowatt can load 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 break downs of any kind. 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.

CONTENTS

Economy Half-Kilowatt (CW Man's Special with VFO) ........................................... page 1-3
Technical Tips (Proper Plate Tank Padding) ............................................................ page 6
Questions & Answers (Bixing Power; Receiver Tube Testing) ................................... page 7
Tricks & Traps (Variable Condenser; Crystal Stretching; Non-Slip Equipment) .......... page 7
Technical Data (GL-4202/1-125A) .............................................................................. Page 8
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 pentode 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, broadband interstage coupling when a high power gain final is used.

Which tube shall we select? Assuming that the buffer takes reasonable preamplification 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 tube with the lowest grid-plate capacitance. It is for this reason that the GL-4021/4-O3A 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 oscillator. This is a practical compromise figure considering both harmonic radiation and circuit efficiency.

Having decided upon the final stage design, the driving stage is next under consideration. From the simplest driving stage a straight RCO using a 5A4 tube seems possible. Under normal operating conditions the amateurs tend to avoid this type of thing because it is considered too crude for the job. The buffer stages in an effort to achieve stability in the VFO must be judged also. The VFO is definitely not capable of flying in under normal conditions if care is taken to see that the VFO is properly loaded (See Technical Tips, Ham News, July-

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

August 1949, 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 QG magazines.

The oscillator shown in Fig. 4 is one of a group of similar principles which have been under test in various ham clubs, primarily that of WJFZV, W6MV mid-1947. The results of these tests have been to show that crystal-like stability can be obtained with a minimum of construction effort and adjustment difficulties. 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 that it was possible to use a GL-1514 tube as the control tube to obtain a moderate output. The circuit is not extremely well suited for this reason as it is not normally used in the conventional RCO circuit.

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

- **$\text{L}_1$**: 20 T, same as $\text{L}_2$
- **$\text{L}_2$**: 80 meters; 22 T, $\frac{1}{4}$ wire, space wound 6 T per inch on two inch diameter
- **$\text{L}_3$**: 2.5 millihenry RF choke (Miller #34100)
- **$\text{L}_4$**: 1 millihenry, 600 mili RF choke (National #135)
- **$\text{R}_0$**: 0.1 meg $\frac{1}{2}$ watt
- **$\text{R}_1$**: 100 ohm $\frac{1}{2}$ watt
- **$\text{R}_2$**: 10,000 ohm, 10 watt, metal-inductive (Sprague 100H, 10W, 10000 ohm)
- **$\text{R}_3$**: 150 ohm 1 watt
- **$\text{R}_4$**: 25,000 ohm, 25 watt, semi-adjustable

A milliammeter may be connected across $\text{R}_2$ to read current across the $\text{GL}-1514$, and similarly a meter across $\text{R}_4$ will read plate current to the oscillator. Jacks could be substituted for resistors at these points. Resistors $\text{R}_2$ and $\text{R}_4$ form the screen bleeder.

The plate coils are wound in Miller #34901 permeability tuned plug-in coil forms. Peeling condensers for each plate coil are wired directly across the coils inside the coil shield (see Fig. 3). The use of these coil plug-in forms permits across voltage changes when going from 30 to 60 meters.

The GL-1514 is designed to have an output, when doublet of 4000 volts required to drive the GL-4212/1-A 25kW Final. One-half of this power, approximately, is absorbed by the loading resistor $\text{R}_4$, when the radiating tube is working straight through an excess of power is available. In order to cut this power back to the proper amount, the screen voltage is dropped from 4500 volts down to less than 200 volts. This is done by changing the direction on plo 6 of the plate coil socket over to plo 7. This change is automatically made when coils are changed. The net effect of this change is to reverse the screen leads of the top and bottom on $\text{R}_4$ rather than off the top of $\text{R}_4$. The adjustment of the position of the tap will be discussed.

Condenser $C_3$ is not a cathode bypass condenser but is actually a part of the cathode-to-ground.
Fig. 3. Under-chassis View of Economy Hall-Klisswell.

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 shielded box is shown in Fig. 6. The grid coil, described previously, is centered to a piece of polyethylene 5/16 inches long and 1/4 inches 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 is mounted directly on the shield box and the shank then extends far enough so that it connects to the National Voltaic Vernier dial on the front panel. Condenser C similarly mounts on the shield box directly behind C. Tuning of C is done from the rear. Fixed condensers C and C 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 insulated plug and plug are mounted on the rear of the chassis to be in filament voltages and plate voltage for the oscillator and final plates. Filament voltage for the final is wired to four of the pins, with two pins being in parallel for each jack. This is done so that the relatively heavy current (0.5 amperes) does not cause any appreciable voltage drop. The other four pins are used for bias, +250 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 frame. The (GL-4521)/4-12.5A tube socket is mounted underneath the chassis, with the only shell grounding clips being above chassis. A 2½-inch hole is made in the chassis on a center which is two inches from the rear panel and eight inches from the right hand side of the chassis. The use of a National 200-200 is recommended in this type furnishes the clips which connect the base shell of the GL-4521/4-12.5A tube.
The location of the tuning condenser, C1, final tank coil, L1, r.f. choke L and blocking condenser C2 is seen in Fig. 1. There is ample room for the 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 currets, such as grid current and oscillator plate current, care would have to be taken to see that undesired feedback was avoided. The layout of the transmitter has been arranged to avoid feedback. Note in Fig. 3 how the high voltage lead which runs from the Miller 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 polyethylene. An extra strip of poly (4½ x ½ a 1½ inches) is wrapped 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 4½ 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 the oscillator. There might be enough drive for the final, but only if the voltages were raised on the oscillator tubes.

This would bring about complications, probably necessitating the changing of resistors R1, R2, and R4. Perhaps a simpler method would be to redesign the oscillator stages so that it operated on 7 megacycles instead of 3.5 megacycles, in case L2, C1, C2, C3, and C4 would probably have to be changed in value. A further point is that for operation on other than 2.5 and 7 megacycles the r.f. choke in the final, L3, would have to be carefully checked to insure that it had sufficient impedance on the 20 meter band.

TUNE-UP PROCEDURE

The first step is to substitute the meter coils in the plate circuit of the oscillator and the final grid circuit of the oscillator. Connect the meter to the final, and disconnect R1 from the source of the final. This is done so that the final voltage will not be applied to the final tubes when no plate voltage is present. Next, apply 500 volts to the oscillator. Set C1 so that the plates are approximately two-thirds meshed. Then, insert a transmission receiver which is calibrated, set C2 until the frequency generated by the oscillator is approximately 3.5 megacycles. With the 40 meter plate coil in place (L1), read and record the current. Now, no voltage on the final this current will be in the order of 15 ma. This current should be maintained by tuning the slug in coil L1 after the frequency has been shifted to approximately 3.5 megacycles (midway on the oscillator tuning dial).

The next step is to put across and plate voltage on the final. Reconnect R1 and correct the high voltage to the high voltage terminal. The final should be tuned to resistance and loaded, preferably with a dummy load, until it reads approximately 100 to 200 ma. Note the grid current to the final under these conditions.

The cells should now be changed to the 80 meter

---

**Fig. 6. Detail View of Oscillator Grid Circuit.**

The final again loaded to the same point, note the final grid current after peaking L1. If it is now necessary to adjust R1 (plate voltages should be removed while this adjustment is being made) until the grid current to the final is the same as 80 meters as it was on 40 meters. Adjustment of R1 has no effect on the grid current on 40 meters but has caused a drop of the grid current on 80 meters. R2 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 ma.

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 ma and 2.5 ma, respectively. For straight-through operation, these currents will run about 25 ma and 1.5 to 2 ma. No antenna coil is used 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 polyethylene strips on a diameter to slide over the main coil will serve very nicely.

---

**PERFORMANCES**

The stability of the completed oscillator was entirely sufficient for all practical work 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 an experimental instrument would find negative feedback capacitance across the main tuning condenser a decided advantage.

The keying characteristics and stability of the oscillator is a decided advantage over the crystal oscillators against which it has been compared.

Parallel-wire the Economy Half-Kilowatt is a beautiful performer. For example, the transmitter plate circuit, which had no parallel-wire suppression of any sort, had 1000 volts applied to the plate circuit. The high voltage was fed to the plate circuit without any 2 ms. Under these conditions no trace of oscillation could be detected on the high voltage. This is an excellent condenser with any combination of cells in place. Many of the so-called neutralized rigs will not pass this sort of test.
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 in a lower frequency. This involves wiring around frequency multiplier stages and using new antenna systems. It also involves worrying about the fact that the tuning condensers are of too low a capacitance to suit the requirements for a proper Q. The usual reaction to this problem is to parallel the old condensers with fixed capacitance, for 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 worryings need be done. Padding capacitance may be added directly across the tuning condenser and the circuit will not be changed effectually 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 gridmills. These gridmills 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.

Fig. 7 A, B, and C is one which is commonly used with either a single tube or a push-pull circuit. Here the tuning condensers and C1 are 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 a very low impedance to the fundamental frequency of the current. However, current is also coming from the tube at radio frequencies which are in substance the fundamentals of the harmonic 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. For the inductive action as a choke and the capacitive action 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 C1, and thence to ground.

If our 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 ants 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 C1 has been replaced with a split-stator condenser C2. 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 harmonic frequencies), or whether to go through the split-stator condenser C2 (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 C2. Before we start peeling this circuit too closely, however, let us examine it more closely. The two halves of the coil are coupled together and the center-top is rather firmly tied to ground through condenser C4. If these two halves of the coil are overcoupled, as is usually the case, then the resonant C1 is out of phase with the coil and there is a double hump. This is a nasty situation because it is almost impossible to go properly. If C1 is set for the resonant frequency, then the impedance of C4 is not as high as it should be, and C3 is tuned so that the impedance is correct, then the circuit is out of phase.

This situation may be avoided by a few quick tricks, which bring the center-top of the coil and the center of the grounded, with the choke disconnected from the center of the coil, or any combination of elements above. The important thing is to omit the bypass condenser which you

(Continued on page 61)
TRICKS AND TOPICS

How did you solve that last problem that almost had you stumped? Do it about tubes, antennae, circuits, etc. Lighthouse Larry would like to tell the rest of the hams about it. Send it in! For each "tick", published you win $10 worth of QSL Electron Tubes. No entries earned. Mark your letter "HORIZON TRICKS AND TOPICS" and send worthwhile to: Old Larry, Tube Division, QSL, General Electric Company, Schenectady, New York, or in Canada, to Canadian General Electric Company, Ltd., Toronto, Ontario.

VARIEABLE CONDENSER
Several types of air variable condensers are now on the surplus market at very low prices. Their main disadvantage lies in the fact 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. 1.)

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 filament. I found that these-stunts did not always work too well and have just substituted a simple crystal oscillator.

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

POLY WRENCH

POLY ROD

Small compact test instruments are a popular tool among handy hams. From experience I've found that the exterior surfaces of these instruments are usually made with a very slick surface. This may result in slipping when the unit is accidentally pulled by the leads. In my case it resulted in the breakage of the instrument. 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.

W3TFV/REX.
TECHNICAL TIDBITS (cont’d)

**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 mode is capable of dissipating 125 watts, and coating is accomplished by radiation. The cathode is a thoriated-tungsten filament. Maximum ratings apply up to 120 megacycles.

**GENERAL CHARACTERISTICS**

- Number of electrodes: 4
- Cathode
- Filament voltage: 5.0 volts
- Filament current: 0.5 amperes
- Grid-screen amplification factor: 6.2
- Impedance capacitances
- Grid No. 1 to plate: 80 μm microfarads
- Impedances
- Output: 31 μm microfarads
- Transmission lines: L = 80 μm, C = 2500 μv, E = 690v, 2450 microhms

**Without external shielding, base shell connected to ground.**

Electronics Department

**GENERAL & ELECTRIC**

Schenectady, N. Y.

(In Canada, Canadian General Electric Company, Ltd., Toronto, Ont.)

Printed in U.S.A.