G-E Electronic TUBE

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VFO Design and Construction

Circuits and Construction Hints for VFO Design

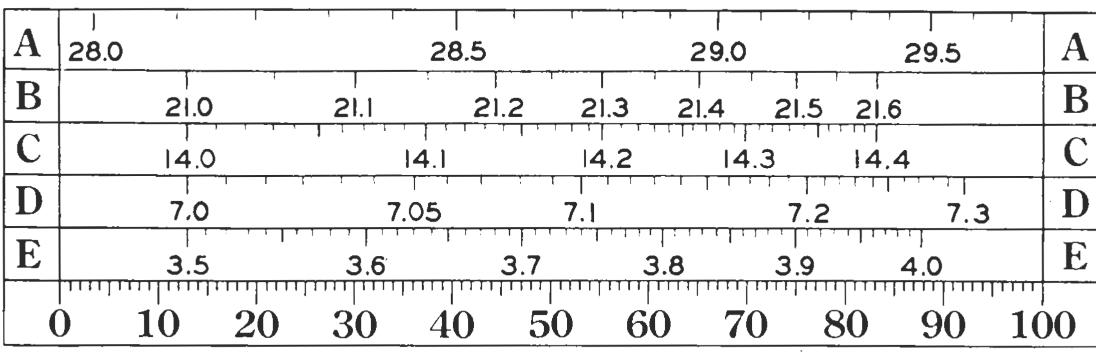


Fig. 1. Dial Calibration of Five-band VFO

A quick look across most of the low frequency ham bands will show that VFO operation is very prevalent, and that those who use a VFO are working more stations per call, and of course, more DX. There is really no need in stressing this point as most amateurs would like to have a variable frequency oscillator. For this reason two issues of the G.E. Ham News will be devoted to describing how an effective "custom-built" VFO may be constructed.

This issue will discuss design in general, and include formulae for computing bandspread and tracking. The proper mechanical and electrical precautions will be given, and a recommended circuit will be shown. The following issue (November-December) will present a five-band, single-dial control VFO, capable of 30 watts output, using only two tubes in the radio-frequency section. The data contained in these two issues of the G.E. Ham News should enable any amateur to design a VFO to his own requirements, especially in regard to frequency bands required, and to his pocketbook.

INITIAL REQUIREMENTS

With no regard to their respective importance, the factors to be considered in any VFO design are: Frequency stability, reset accuracy, direct output on any desired band, and economy. There are other factors, but these four are the major ones. Consider them one at a time. It is not difficult to design and build a VFO with moderate stability. Moderate stability means a usable stability—one which compares favorably with the average crystal in use today. If you desire a VFO which will compete with WWV you indeed do have a problem—and one which will not be solved here.

Reset accuracy is self-explanatory. It is desirable to be able to go to a certain frequency with sufficient accuracy that you will be heard by any station looking for you at that point. This will not be ±2 cycles, but again it is usable reset accuracy desired.

Direct output on any band desired is extremely desirable, if this can be obtained without a string of multiplying stages. This problem is more easily solved than you might imagine. It is a relatively easy job to have output on 80, 40, 20, 15, and 10 meters, using only two tubes, an oscillator and an output tube. Doubly desirable is good power output. Again, this is easily done.

Economy is the biggest problem of all, as it is impossible to have all the gadgets on a VFO unless you are prepared to pay a fancy price and also spend a lot of time building a fancy VFO. Note that it is not necessary to sacrifice quality—only flexibility and convenience. After all, an extremely simple VFO is just up one step from a fancy crystal oscillator as far as convenience is concerned. Possibly the first step in the design of your VFO is to determine what you can afford, and then to see if this will give you the type of VFO that you require.

THE OSCILLATOR

Many types of oscillators can be used to generate a radio-frequency signal, and most of these types (ECO, Hartley, tuned-plate grid tickler, tuned-plate tuned grid and negative transconductance) have been used in VFO design. All of them, properly applied, will give a satisfactory VFO. The ECO was chosen because it fits in with more of the requirements which were subsequently found necessary. The schematic diagram, Fig. 2, gives the basic circuit for the electron-coupled oscillator to be used in the Five-band VFO.

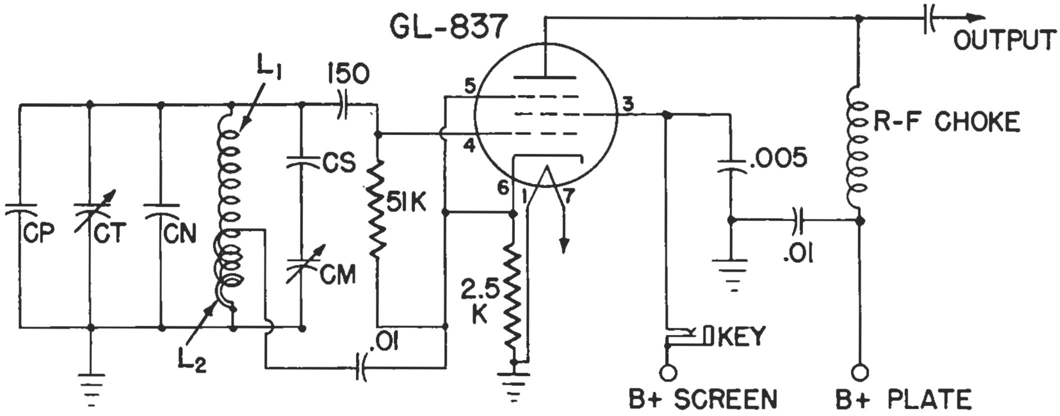


Fig. 2. Circuit Diagram of One-band ECO

The ECO circuit is standard in all respects but one. Cathode current does not flow through the cathode coil. Instead, the cathode is coupled, through a 0.01 mf. condenser to the cathode coil and a 2500 ohm resistor, connected directly to the cathode, provides cathode bias. This change was made in order to reduce any heating which might be produced by the cathode current flowing in the coil.

Frequency is determined by coil L_1, and its associated capacitors, CP, CT, CN, CS and CM. CP is a relatively large value and is used for padding, that is, it provides the main bulk of capacitance used. Ceramic condensers are ideal for this purpose. CT is an air trimming condenser, and is used to set the frequency exactly where desired. CN is a small negative coefficient condenser to provide drift compensation. Actual tuning is done with CM, and CS is used in series so that the bandspread may be adjusted to exactly fit on the tuning dial.

As an example, if it were desired to make this oscillator operate from 1.75 to 2.0 megacycles, the following values could be used. CP—200 mmf; CT—140 mmf; CN—20 mmf; CM—140 mmf; CS—0 mmf. It will be seen that the total capacitance across L_1 is thus 500 mmf. It is desirable to keep this high in order to achieve stability. In the case just given, correct bandspread could be achieved without using any series condenser (CS) although this is an exception.

Calculation will show that the coil required in the example given is one with an inductance of approximately 16 microhenrys. Coil L_2 will be approximately one-third of this value, although coil L_2 is mainly a matter of cut-and-try. Coil winding is difficult and tedious in many cases, but this big problem can be gotten around by the use of Barker & Williamson "MINIDUCTORS." These coils come in 16 different sizes and may be cut to any length desired. In addition, two different diameter coils fit snugly over one another so that a cathode coil, such as L_2, may easily be coupled to the main coil.

Fig. 3 shows two of these B & W coils formed into one unit. The inner coil (B & W 3010) has a diameter of ¾ inch and has eight turns per inch, whereas the outer coil is one inch in diameter and thus fits nicely over the inner coil. The large coil (3014) has the same turns per inch as the small one. It has been cut so that 6½ turns remain although it was, before cutting, three inches long with 24 turns. These B & W coils take most of the hard work out of making coils, and they are wound on small pieces of polystyrene which will not cause frequency drift due to temperature change. This is important because if coils were wound on bakelite or ceramic material, or even a solid piece of polystyrene, temperature changes would cause these materials to change shape, and the subsequent change in coil size might cause a serious frequency change.

A single-band ECO can thus easily be made with the circuit described. The plate circuit and a subsequent buffer tube will be discussed later, but the essential element—the oscillator tube—may be as simple as just described. It is the least fancy type of VFO. A slight change would make a more flexible unit. In Fig. 4 is shown a SPDT switch which changes CS so that two types of bandspread are available. This could be used to change the bandspread from 3.5—4.0 mc. to 3.85—4.0 mc giving complete coverage of the 80 meter band or specialized coverage for 75 meter phone work.

To get fancier still, a band switch could be used to change grid circuit constants so that more than one band could be covered. This idea may be extended as high as 20 meters, without getting into undue drift or a poor note. This statement may seem like heresy to some amateurs, but nevertheless it is not difficult to build an oscillator for operation on 14 megacycles. The drift in frequency will be no worse at 14 megacycles than that which results from using a 3.5 mc. oscillator and quadrupling. Remember, the frequency change quadruples also.

A GL-837 tube is shown in the oscillator circuit. Many tube types will work—although perhaps not as well. A large tube was selected in order to get a moderate amount of output and so that a broad-tuned plate circuit could be used. Also, it seems more desirable to let a large tube loaf along than to run a smaller tube at full ratings. Further, the GL-837 is designed for VFO service and is therefore a logical choice.

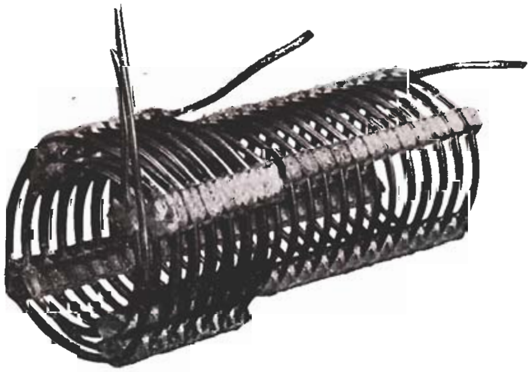


Fig. 3. Grid Coil Made with B & W Miniductors

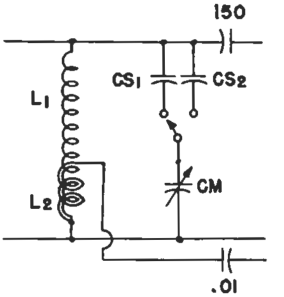


Fig. 4. Circuit Diagram for Bandspread Change

FREQUENCY CALCULATIONS

Let us assume that you want to calculate the necessary L and C for the circuit in Fig. 2 for a given band—say 1750 to 2000 kilocycles. First, you must select a value of total capacitance (CP+CT+CN+CM+stray). This is not difficult, and as a starter you should use 500–1000 mmf for 160, 80 and 40 meters, and 300–600 mmf for 20 meters. Call it 500 mmf in this case. The next step is to find the capacitance variation necessary to tune across the band. The formula for this is:

$$CX = (C\ \text{total}) \left(\frac{F2}{F1}\right)^2$$

F1 is this highest frequency, F2 the lowest frequency, and C total is our selected value of 500 mmf. Working this out gives us a value for CX of 383 mmf. This means that 500 mmf will tune to 1750 kc and 383 mmf will tune to 2000 kc. Therefore, the variable condenser must change 500–383 or 117 mmf. A standard 140 mmf. condenser could be used, as it probably has a minimum capacitance of 20 mmf, and thus changes 140–20 or 120 mmf total.

We now know that CM is 140, and that CS is not required. If we happen to have a 100 mmf air trimmer, this can be used for CT. These two condensers (CM and CT) total 240 mmf, so that the rest of the capacitance, to total to 500 mmf, must be 260 mmf. We can use a CN of 10 mmf, leaving a CP of 250 mmf. This completes our calculation for the various capacitances needed.

The next step is to determine the inductance of L_1. Most handbooks have a table giving the proper inductance to use to tune to a certain frequency using a given capacitance. Once this value is found, the number of turns and the diameter may be calculated from the handbook data. You may neglect the effect of coil L_2. Select a B & W coil near the proper size, or make an air-wound coil, and then make L_2 approximately one-third the size of L_1. This may be changed later, but it is a good start.

When the complete circuit is wired, check the frequency with CM fully meshed. If it is lower than 1750 kc take out capacitance by means of CT, or vice versa. The bandspread is now checked by moving CM through the entire range. If you find that you are unable to get the entire band on the dial CM is too small and should be made larger. If the band does not cover enough of the dial more bandspread is needed, which requires making CM smaller. It is not necessary to change the condenser. Merely add condenser CS. For example, if CM is 140 mmf and there is not enough bandspread, add CS of, say, 140 mmf, and then CM is effectively only 70 mmf and twice the bandspread exists. It would be of course necessary to add an additional 70 mmf to CP in order to get the frequency back to the same point, as CM and CS in series now give only 70 mmf instead of 140 mmf as before.

OSCILLATOR PLATE CIRCUIT

So far, we have considered only the frequency-determining part of the oscillator. The plate circuit may be just as important as the grid circuit, because if certain precautions are not observed, we will find that the grid circuit will change frequency due to things happening in the plate circuit. This may even be caused by actions which take place in the buffer stage.

It is possible to take the circuit in Fig. 2 and add a tuning condenser and coil in the plate circuit (instead of the r-f choke shown). The coil would be resonant at the frequency generated by the grid circuit. The tuning condenser would allow us to peak the plate circuit, and thus we would be able to drive any other tube desired. This system would work perfectly if our mechanical and electrical design were also perfect. It is much safer not to tune the plate circuit, if frequency stability is desired. In other words, the less we do with the plate circuit, the less the plate circuit is likely to affect the grid circuit.

An untuned plate circuit is shown in Fig. 2. It consists of an r-f choke, which in reality is a broadly resonant coil and condenser combination. The capacitance exists due to the turn-to-turn capacitance in the r-f choke itself. A mica or ceramic condenser couples this stage to the following stage. A plate circuit of this sort has one disadvantage over the tuned circuit, in that less output will be obtained. However, it is undesirable to take a lot of power from an oscillator, so that the untuned plate circuit is ideal in this case.

The r-f choke shown may be the usual type of 2½ millihenry choke, especially if operation is

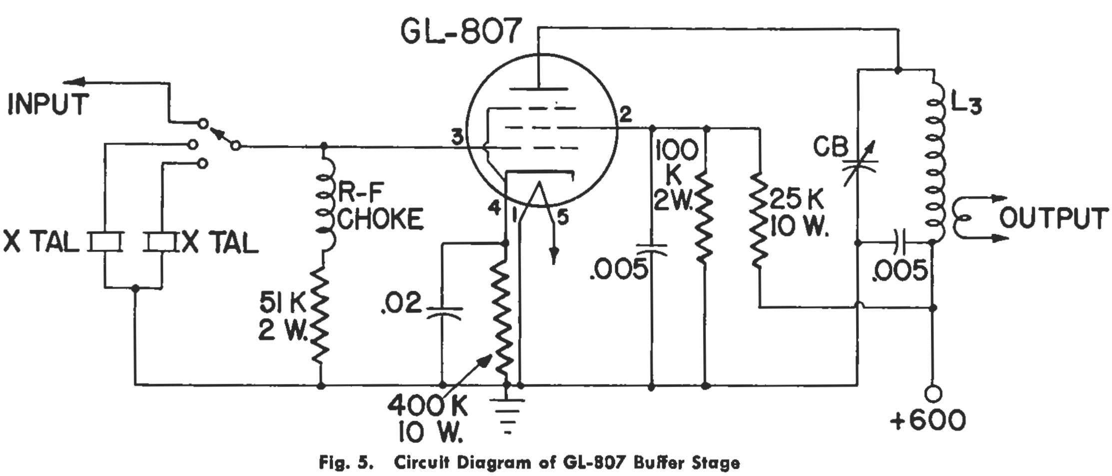


Fig. 5. Circuit Diagram of GL-807 Buffer Stage

TABLE I

GL-837 PLATE COILS

WAVELENGTH	WINDING	NO. OF TURNS	LENGTH	DIAMETER	NO. OF WIRE
160	Layer wound	125	1¼	½	26
80	Layer wound	70	⅞	½	26
40	Close wound	60	1¾	½	22
20	Space wound	28	2	½	22

contemplated on 160 or 80 meters. If this type of r-f choke is used on the higher frequencies, the output will be so low that it will not be usable. It is therefore better to think of the r-f choke as a broadly resonant coil, and wind your own. Circuit efficiency will be increased and the output resulting will be more than ample.

Table I gives the details for winding broadly resonant tank coils. These may be wound on any type of form, such as bakelite, poly or ceramic. Different circuit layouts may change the resonant frequency of these coils, but the figures in the table will do to start with. The coils may be checked by tuning the oscillator circuit across the entire band, and checking the grid drive to the next stage. If the grid current to the driven stage is relatively constant, the coils are all right. If the grid current falls off at one end or the other, it would be necessary to use a few more or a few less turns.

Using broadly resonant coils such as these is economical, because no condenser of any sort is needed in the plate circuit, and in addition, no tuning need be done. Lastly, the circuit should be less critical and give better performance.

THE BUFFER STAGE

The oscillator stage we have just described can be considered as a complete VFO all by itself. Actually if perfect design and construction had been followed, it would give results which would leave nothing to be desired. However, due to many items beyond the control of the builder, it is better to go a step farther and incorporate into our VFO a second stage. This buffer stage will do two things. One, it will protect our oscillator stage from frequency change, as the buffer stage will live up to its name and act as a buffer between the oscillator and subsequent tubes. Second, we shall be able to build up our power to a point where a quite respectable output may be obtained.

The tube we use in the buffer stage should be capable of moderate power output and yet not require too much driving power, as we do not wish to overload the oscillator. Also, if we wish to avoid neutralization, it should be a pentode or a beam-power tube. These qualifications bring us quite naturally to selecting a GL-807 as the buffer tube. Because this tube is so easy to drive, we can use it as a doubler or a tripler, which allows us greater flexibility in the VFO design.

Following along this line of reasoning, it would be desirable to have the GL-807 act as a multiplier in all cases, rather than working straight through, so that we can design the GL-807 stage as a frequency multiplying stage. It is now obvious why we have discussed 160 meter operation of the oscillator. For operation on 80, 40, 20 or 10 meters, the oscillator would be respectively on 160, 80, 40 or 20 meters. We can operate on 15 meters by using the oscillator on 40, and tripling in the GL-807.

A recommended circuit for the buffer stage is shown in Fig. 5. The single-pole, three-position switch in the grid circuit allows the GL-807 to be driven by the ECO or to act as a crystal oscillator when either of two crystals is switched into the grid circuit. The 400 ohm cathode resistor and the 51,000 ohm grid resistor provide approximately 150 volts of bias. This is necessary if good efficiency is to be obtained in a frequency multiplier stage. The cathode resistor also provides protective bias so that plate current will not rise excessively as the oscillator is keyed.

For a simple VFO, the buffer stage may be used as shown, with a tuning condenser, CB, brought out to the front panel, and a plug-in coil used as L_3. A slightly more complicated system could be made by ganging CM with a padding condenser across L_3. This would allow single dial control. Refer to Fig. 6. In "A," CB is the main tuning condenser. If it is desirable to gang in order to have single dial control, a second condenser, CD, must be added. This latter condenser has a low capacitance which has just sufficient range to tune over the desired band.

For example, let us assume that the buffer is on the 20 meter band, and that CB is 50 mmf. The coil would be a plug-in coil either manufactured or home-made. Using the formula given previously, to tune from 14,000 to 14,400 kc requires a CX of 47.2 mmf. This value, subtracted from 50 mmf, gives us a range of 2.8 mmf required for CD. This value is rather low, and it would be difficult to find a condenser of this sort. For this reason we use the circuit shown in Fig. 6 "B."

By placing a tap on L_3 approximately half-way down the coil, we find that condenser CE should be approximately four times our computed value. Thus CE should be about 11.2 mmf. This value of air condenser is relatively easy to find, as a 15 mmf condenser would serve nicely. Carrying this process a bit further we can see that a trimmer condenser can be almost an odd value that you may happen to have handy, and it will work if it is tapped into coil L_3 at the proper point. This proper point is of course found by cut and try.

It is quite likely that once the proper tap point is found, a check across the band will indicate that CM and CE are not tracking perfectly. This could be caused by the fact that the two condensers are not changing capacitance in the same way. In other words, it is possible that when both condensers are at minimum capacitance, and at maximum capacitance, they are perfectly matched, but that in between maximum and minimum capacitance they do not follow the same capacitance curve. This can usually be neglected, as the GL-807 tank circuit, when loaded, should be broad enough to smooth out any such differences.

This tracking stunt will work for only one band, as it will require different values of CE to track each band. The next step toward a more complex VFO is therefore to put bandswitching in the GL-807 plate circuit, so that separate coils and separate condensers (both CB and CE) are switched in at will. Condensers CE1, CE2, etc., for each band would be ganged with CM. This gives us the most complicated of the VFO designs. For, if we have separate tank coils, we can also have separate output links, so that separate finals may be added, or separate antennas used. The latter gives us a single dial control, single-switch transmitter with 5-band operation, with no antennas to change.

MECHANICAL PRECAUTIONS

The best VFO circuit will work only poorly, or perhaps not at all, unless the actual construction is well planned. It is not possible to make a set of rules to cover every contingency, but some general rules can be made. Since the oscillator grid circuit is the frequency-determining element, special care must be taken at this point. The tuning condenser, CM, should be rigidly mounted, and it is sometimes well to use a flexible coupling to drive this condenser in order to prevent shocks on the tuning dial from reaching the condenser. Another wise precaution is to mount the entire oscillator circuit on shock-mounts. This not only tends to relieve the oscillator section from all incidental shocks, but it also isolates the circuit from power transformer vibration. Incidentally, unless shock mounts are used, the power equipment should not be used on the same chassis with the oscillator.

The grid circuit should be wired with heavy wire, so that each individual connection has no chance to move in relation to other parts. The heavy wire also lessens vibration effect. All components, such as resistors and condensers, should be rigidly fixed to tie points for maximum stability. The above points are good wiring practice for any circuit, but are doubly important for VFO construction.

Heat is another problem. Any heat producing unit should be kept as far as possible from the coils and condensers in the oscillator grid circuit. Further, the coil and padding condenser for each band should be mounted as close to each other as possible, and the temperature compensating condenser mounted directly on either the coil or the padding condenser. Shielding can be used to advantage to keep heat away from the grid circuit constants, and also serve as an r-f shield. A thoroughly shielded VFO is a necessity if r-f from the final is to be kept out. (Any stray r-f in the VFO will cause a poor note and instability.)

TUNE-UP PROCEDURES

A completely wired VFO is by no means a good VFO, until several adjustments have been made by the builder. If the circuit used is an ECO, the adjustment of the cathode coils would be a good place to start. An optimum number of turns exists for each cathode coil which will give a minimum frequency change for a given plate voltage change. The tests consist in changing the plate voltage to the oscillator tube, and checking the frequency on a warmed-up communications receiver. If the frequency increases due to a plate voltage decrease, there are too many turns on the cathode coil. Similarly, a frequency decrease with a plate voltage decrease means too few turns. Adjustments should be made until the frequency change, due to a 50-volt plate change, is under several hundred cycles.

Another important adjustment is that of plate-screen voltage on the oscillator tube. With each tube and circuit an optimum ratio of plate to screen voltage exists. When the correct ratio is obtained, a minimum of frequency change will result. This again is a cut-and-try proposition, but one which is very worth while.

If temperature compensating condensers are used further adjustment is needed. Referring to Fig. 2, CN and CT are the condensers in question. They are adjusted by listening to the signal on a receiver, and then deliberately adding heat to the oscillator grid circuit. An infra-red heat lamp is ideal for this. If the frequency increases as the temperature rises, add capacity in the negative temperature coefficient condenser (CN) and take out capacity by CT so that the frequency comes back to the same point. Keep this up until the frequency is as constant as possible, due to heat increase or decrease.

KEYING

There are always a number of keying methods to choose from but one which has been found to be good in most cases is oscillator screen keying. If the screen circuit is opened, that is, the screen voltage removed, the keying that results is clean and crisp. If it is desirable to key the buffer stage also, assuming that fixed cut-off bias is not used, the cathode of the buffer tube can be keyed at the same time, as the oscillator screen, by means of a relay.

Clicks may appear due to almost any keying system, but this is an individual matter which will vary from set-up to set-up. These can usually be cleared up by a resistance capacitance filter across the key contacts.

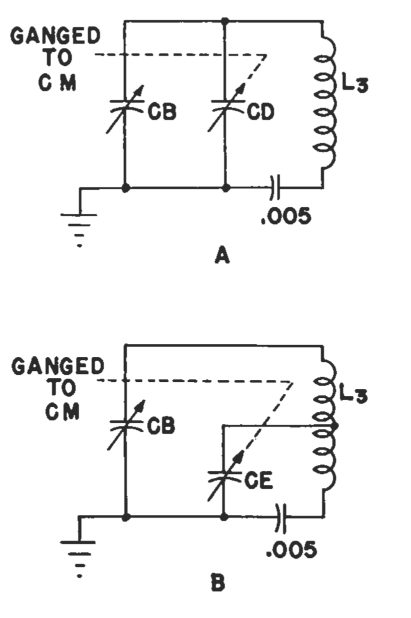


Fig. 6. Circuit Diagram of Two Tracking Systems

FREQUENCY CHART

80

1.75	1.80	1.85	1.90	1.95	2.00
3.5	**3.6**	**3.7**	**3.8**	**3.9**	**4.0**

40

1.75	1.775	1.80	1.825
3.50	3.550	3.60	3.650
7.0	**7.1**	**7.2**	**7.3**

20

1.75	1.7625	1.775	1.7875	1.80
3.50	3.525	3.550	3.575	3.60
7.00	7.050	7.100	7.150	7.20
14.0	**14.1**	**14.2**	**14.3**	**14.4**

15

5.25	5.275	5.30	5.325	5.35	5.3625
10.50	10.55	10.60	10.65	10.70	10.725
21.0	**21.1**	**21.2**	**21.3**	**21.4**	**21.45**
10.50	10.550	10.600	10.650	10.700	10.725
3.50	3.517	3.533	3.550	3.566	3.575
1.75	1.758	1.766	1.775	1.783	1.7875

11

3.395	3.4062	3.4175	3.4288
6.79	6.8125	6.835	6.8575
13.58	13.625	13.670	13.715
27.16	**27.25**	**27.34**	**27.43**
9.053	9.083	9.113	9.143
4.5265	4.5415	4.556	4.5715

10

3.5	3.5625	3.625	3.6875	3.7125
7.0	7.125	7.25	7.375	7.425
14.0	14.250	14.50	14.750	14.850
28.0	**28.5**	**29.0**	**29.5**	**29.7**

6

6.25	6.375	6.5	6.625	6.75
12.5	12.75	13.0	13.25	13.5
25.0	25.50	26.0	26.50	27.0
50	**51**	**52**	**53**	**54**
16.666	17.0	17.333	17.666	18.0
8.333	8.5	8.666	8.833	9.0
4.167	4.25	4.333	4.417	4.5

2

12.0	12.083	12.166	12.25	12.333
36.0	36.25	36.50	36.75	37.0
72.0	72.50	73.0	73.50	74.0
144	**145**	**146**	**147**	**148**
48.0	48.333	48.666	49.00	49.333
16.0	16.111	16.222	16.333	16.444
8.0	8.055	8.111	8.166	8.222

QUESTIONS AND ANSWERS

Do you have any questions about tubes or tube circuits? Lighthouse Larry would like to answer them for you. For each question published you will receive $10 worth of G-E electronic tubes. All questions not published will be answered promptly by mail. Send your questions to Lighthouse Larry, Tube Division, Bldg. 269, General Electric Company, Schenectady, New York or in Canada to Canadian General Electric Company, Ltd., Toronto, Ont.

Question: Assume that a tube is being used as an r-f amplifier. Does it harm the tube if it is run with the filaments on, and grid drive applied, even though no plate voltage is used on the tube? Is the life of the tube affected by running it this way?—WϕVFM.

Answer: If a tube is operating at the correct operating point, and then the plate voltage is removed, the grid current, and hence the grid dissipation, will increase. If this increase makes the grid dissipate more than it is rated to dissipate, the tube may become gassy. Of course, if this increase still does not cause the grid to exceed dissipation limits, no harm is done to the tube.

The life of the tube is being shortened whenever the filament is on, whether or not grid drive or plate voltage is applied.—Lighthouse Larry.

Question: In using GL-813 tubes both as single-ended amplifiers and as push-pull amplifiers I have noticed that a variation of several hundred per cent in grid drive produces no appreciable variation in the output. What tube characteristics cause this, and how can a proper value of grid drive, with maximum output and tube life, be determined?—W8OPG.

Answer: In a screen-grid tube, such as the GL-813, the number 2 grid (screen) is always operated at some fixed positive voltage. This voltage on the screen grid has a much greater effect on the plate current than the plate voltage. In other words, the plate current is more easily affected by a screen voltage change than by a plate voltage change.

Consider a tube operating with a given output circuit, a given plate voltage and a certain screen voltage. When the control grid is driven by the driver stage, the driving voltage causes the grid to be positive and negative, at a radio-frequency rate. Increasing grid drive will cause the grid to go more positive, and more negative. When the control grid is driven too far positive, the instantaneous screen grid current will be reduced and no increase in plate current will result. If this were to be carried farther, when the positive grid voltage exceeded the screen voltage, the output of the tube would actually decrease.—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" accepted you win $10 worth of G-E Electronic Tubes. No entries returned. Submit to Lighthouse Larry, Tube Division, Bldg. 269, General Electric Company, Schenectady, New York or in Canada, to Canadian General Electric Company, Ltd., Toronto, Ont.

PANEL MARKING TRICK

The problem of how to mark panels and chassis with tube designations and labels for controls, terminals, and meters keeps coming up every time a new piece of equipment is finished. The easiest and longest-lasting recipe I have found is as follows:

On panels and chassis with a black wrinkle finish, first sand the area to be marked with fine sandpaper, until the paint is fairly smooth. Then carefully letter the legend on in white ink, using an ordinary pen. When the ink is dry, cover the lettering and the sanded area with a smear of clear household cement.

On cadmium-plated chassis, first clean the area to be marked with carbon tetrachloride on a clean rag. When dry, letter with black India ink, then cover with cement.

White ink used for this purpose should be thick (pour some of the water off the top) and the pen should be wiped clean every two or three letters. Do not get too much ink on the pen. The wrinkle-finish on the panel has to be sanded so that the ink won't run into the little crevices on the finish and make a mess. If you do mess up a label, wipe it off quick with carbon tet and start over when it is good and dry.

The cement should be applied with a single swipe. Be careful not to smear it around or brush it back and forth because it softens the ink. If any area is left uncovered, apply another swipe after the first is dry.

If the India ink fails to stick to a cadmium-plated surface, it means that the surface was not really clean and free of grease and fingerprints. Clean it again, good, with carbon tet and try again.

Any transparent, waterproof, cellulose cement is the best thing I have found for covering the lettering. It will not peel off or turn milky in color. The cement restores the original shine to the sand-papered area on wrinkle-finish panels, so that it looks as good as new.—W3HQP.

R-F INDICATOR TRICK

A voltage regulator tube, such as an OB3/VR90 or OD3/VR150, etc., may be used as a handy r-f indicator if more sensitive means are not at that moment available. For low power touch terminal 2 or 5 to the r-f source and the gas inside the tube will glow. For higher power hold the glass envelope in the r-f field and the gas will glow. (Caution: In the latter case do not touch any of the base pins with your fingers.) The more r-f you have, the brighter the glow in the tube, so that a resonance point is indicated by the point of maximum glow.—VE3HG.

TECHNICAL INFORMATION

GL-837

GENERAL CHARACTERISTICS

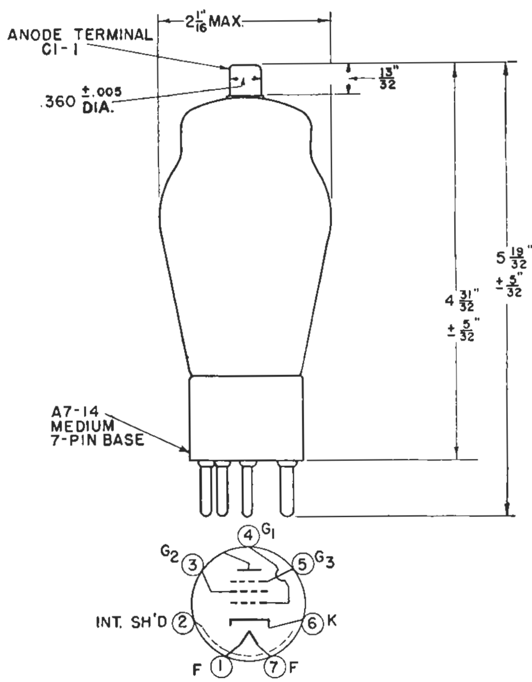
Electrical

Cathode-heater type	
Heater voltage, a-c or d-c	12.6 volts
Heater current	0.7 ampere
Transconductance, for plate current of 24 ma	3400 micromhos
Direct interelectrode capacitances	
Grid-plate, with external shielding	0.20 micromicrofarad
Input	16 micromicrofarads
Output	10 micromicrofarads
Frequency for maximum ratings	20 megacycles

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

As Radio-frequency Power Amplifier and Oscillator Pentode—Class C Telegraphy, Key-down Conditions per Tube without Modulation‡

	Typical Operation			Maximum Ratings
D-c plate voltage	400	500	500	500 volts
D-c suppressor voltage	0	0	40	200 volts
D-c screen voltage	200	200	200	200 volts
D-c grid voltage**	−40	−85	−75	−200 volts
Peak r-f grid voltage	70	120	100	volts
Internal shield	connected to cathode at socket			
D-c plate current	70	60	60	80 milliamperes
D-c screen current	32	30	15	milliamperes
D-c grid current, approximate	8	8	4	8 milliamperes
Plate input				32 watts
Suppressor input				5 watts
Screen input				8 watts
Plate dissipation				12 watts
Screen resistor	6300	10000	20000	ohms
Grid resistor	5000	10600	18700	ohms
Driving power, approximate	0.5	0.8	0.4	watts
Power output, approximate	16	20	22	watts



BOTTOM VIEW
BASING DIAGRAM

**The total effective grid-circuit resistance should not exceed 25000 ohms.

‡Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

The GL-837 is a pentode transmitting tube for use as a radio-frequency amplifier, frequency-multiplier, oscillator and suppressor-, grid- or plate-modulated amplifier. The plate connection is brought out through a separate seal at the top of the bulb to maintain low grid-plate capacitance. Neutralization is generally unnecessary in adequately shielded circuits. The suppressor and the special internal shield are connected to individual base pins. The 837 may be operated at maximum ratings at frequencies as high as 20 megacycles. The maximum plate dissipation is 12 watts.

Electronics Department

GENERAL ELECTRIC

Schenectady, N. Y.

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

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