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Author: Byron Goodman, W1DX

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A 1950 VFO Exciter

Some Ideas for Construction and Keying

BY BYRON GOODMAN,* W1DX

• This is a description of a VFO unit that you probably won't duplicate. But before you decide that it has nothing for you, run through the article and file away some of the ideas. They may come in useful later on.

At first glance this VFO exciter looks like a pretty fancy gadget to give only 15 to 20 watts output on all bands from 3.5 to 28 Mc. (including 21 but not 27 Mc.). Perhaps it is but, being an extremist on some points, we had some pretty fancy requirements to meet. The thing is handy enough, requiring only the changing of one plug-in coil and the turning of a switch to get on any band, but there is an extra tube and a relay on the chassis that are used only for keying, and they don't add any power or bands.

A number of ideas for switchable or plug-in oscillator coils were kicked around and finally discarded in favor of just two oscillator tank circuits. One was to be on 160 meters, for covering the 80- and 40-meter bands, and the other was to be on 7 Mc., to cover the 14-, 21- and 28-Mc. bands. To obtain a decent tuning rate, the 7-Mc. oscillator circuit was cut to just cover the 14-Mc. band, which thus leaves out some of the 28-Mc. band and all of the 11-meter assignment. To include these would require a third oscillator circuit, or a sacrifice in tuning rate, and so they were left out. However, before the next DX Contest comes around we may use a larger padding condenser across the tuning condenser, which will allow the 27-Mc. band to be reached by a little finagling.

All frequency multiplying is done in the oscillator stage (the lowest possible level), and there are several tuned circuits between the oscillator stage and the output amplifier. So far, a block diagram of the VFO would look like Fig. 1. While it may already seem to be taking on an equine appearance, the thing isn't too bad if the three sets of "tuned circuits" are all made fixed-tuned and compact. By running the first and second buffer stages Class A, good isolation for the oscillator is obtained, no new harmonics are generated, and the undesired harmonics generated in the oscillator plate circuit are pretty well attenuated.

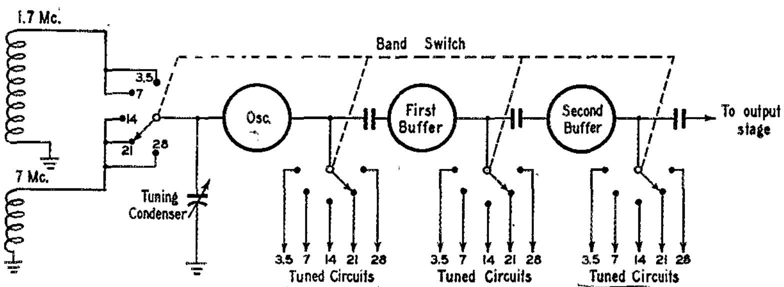
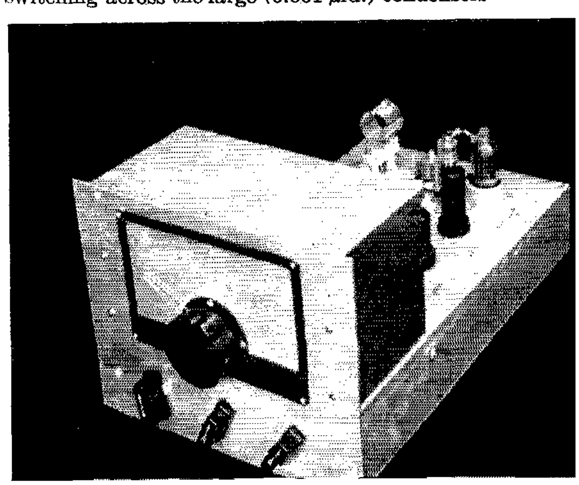


Fig. 1 **— A block diagram of the exciter up to the output stage. All frequency multiplying is done in the oscillator stage.**

One has only to play around a little with the Clapp oscillator circuit to sell himself on it, so there was no hesitation about using it here. Actually, it is a natural for the thing, because it is just about the only oscillator circuit that can be switched with no worries about the quality of the switch affecting the stability of the circuit. "Hey, go slow," you say. Well, look at Fig. 2. By using two separate tuning condensers, C_1 and C_2, and switching across the large (0.001 μfd.) condensers

* Asst. Technical Editor, *QST*.



This 5-band VFO exciter unit has a 2E26 in the output stage and delivers 15 to 20 watts.

of the tuned circuits, the switches are practically out of the circuit. Further, the switch can be mounted a considerable distance from the circuits, by running the leads to the switch in small coaxial line. This keeps the oscillator tube away from the tuned circuits, thus reducing any frequency drift that might be caused by the tube heat raising the temperature of the tuned circuit. It is a dodge that can be applied to any Clapp oscillator, switched or not.

What Tubes To Use?

With these few points settled, the next step was to select the right tubes for the various jobs. A logical tube for the output stage might be the 807. However, we decided on the 2E26 because it is small, can be run at the 25 or 30 watts input that was wanted, and seems to be less prone to parasitic oscillations than its larger cousin. If some kind tube manufacturer ever brings out an 807 with short leads, it will be the logical tube for this unit, but we played it safe for the present and used the 2E26. It was probably just good luck, but there was no trouble at all with parasitics. For the second buffer, the 6AG7 was selected, and 6AC7s were used for the oscillator and first buffer jobs. While this may look like a terrific amount of over-all gain, remember that these tubes work into broad-band (loaded) circuits, with some stagger tuning to give uniform excitation over the range, so the over-all gain is not too high.

It was decided early in the game that the 2E26 would not be driven hard, as one little step in holding down the harmonics, and somewhere between Class B and Class C operation would be accepted as satisfactory. With no excitation, just enough fixed bias was to be used on the 2E26 to reduce the plate current to a safe level, to help out a little on power-supply regulation and to maintain the keying characteristic.[1]

Where To Key?

If you like chirpy keying, we advise you to key the oscillator — any oscillator. To avoid chirps and clicks with oscillator keying requires, first, an oscillator that has *no* frequency change with voltage change and, second, a transmitter that is all linear amplifiers or close to it. We don't say an oscillator that is completely insensitive to voltage changes can't be built — we just say we've never seen or heard one. To avoid clicks, some lag must be inserted in the keying circuit, and this means that the voltage is changing on the oscillator while it is delivering output during

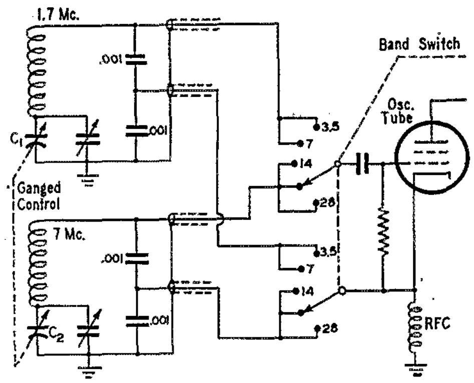


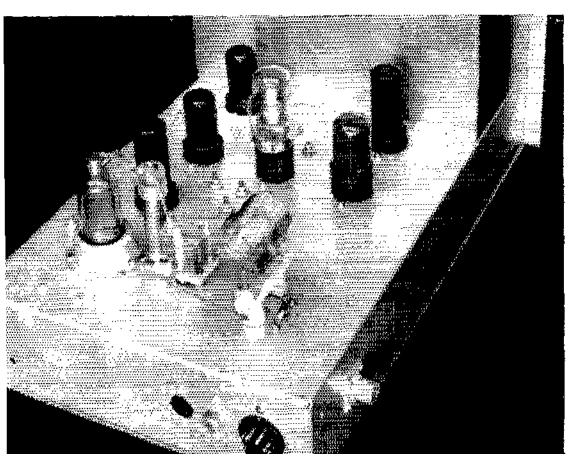
Fig. 2 **— Details of the oscillator switching. The leads from the 0.001-μfd. condensers in the tuned circuits are run to the switch through coaxial line, allowing the tube to be mounted well away from the tuned circuits.**

the "make" and "break" periods. Any frequency change shows up as a chirp. If you don't put enough lag in the circuit, you have key clicks that you can't get rid of, no matter what you do later on. Most operators put up with the chirp, but we like to have a signal that sounds like a keyed amplifier, with no chirps. But we also like to have break-in available! That leads us to the circuit described in *QST* some time back.[2] This was a tube keyer that could be connected in an amplifier cathode circuit and, together with a fast relay and one tube, turns the oscillator on fast before the character is formed and turns the oscillator off after the character is formed. At high speeds the oscillator only goes off between words, but this still permits good break-in operation.

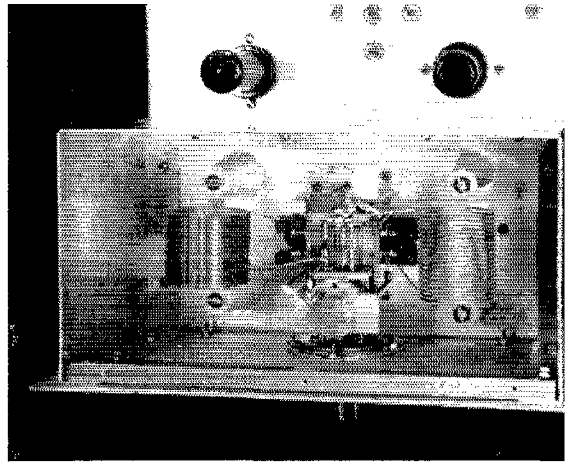
In this VFO, the keyer tube of the earlier cir-

[1] Carter, "Reducing Key Clicks," *QST*, March, 1949.

[2] Goodman, "Improved Break-In Keying," *QST*, March, 1948.



A rear view of the exciter. The 6SN7 and the Millisec relay (in metal tube envelope) to the right of the VR tube are used in the keying circuit. The linear condenser standing alongside the 2E26 furnishes a short return path for harmonics.



The two oscillator tuning circuits are mounted inside the shield can.

cuit was eliminated by using grid-block keying. The second buffer tube was keyed instead of the first buffer to insure better isolation of the oscillator. The 2E26 grid could have been keyed, or even the grid of some subsequent amplifier, but we used it where we did because the 6AG7 is running at low signal and low bias, and a 105-volt negative power supply handles it easily. At a higher level, a higher-voltage supply might be required.

To say that we're happy we included this circuit is a marvel of understatement, because keying the oscillator by itself, with enough lag to eliminate clicks down to where they aren't objectionable, gives a chirp that shouldn't happen to a sparrow. It may be that by suitable juggling of the constants in the oscillator circuit we could have reduced this chirp, but we don't believe they could ever have been eliminated, at least to the point where we would have been happy. As the rig stands, no one can tell the difference between the break-in keying and amplifier keying with the oscillator running continuously, simply because there is no practical difference. We're using break-in with an oscillator that chirps when keyed, and yet the signal has no chirp — you can't ask for much more than that.

To digress a minute, we know that there are three other approaches to this "amplifier-type break-in keying." One is to use a continuously-running oscillator that is well-shielded and on a low frequency, another is to use a conversion exciter and key the mixer, and the third is to locate the continuously-running oscillator and keyed amplifier a considerable distance from the receiver. The first two should be capable of every bit as good performance as the unit being described — they just don't happen to appeal to the writer — and the third involves financial and housing facilities that are beyond the writer — and a few others. All we want to put across right now is that you have to lower your standards of keying if you key the oscillator for break-in work, particularly at the higher frequencies. If you are one of those with a "chirpless, clickless" keyed oscillator, just listen to it with a low beat note at 28 Mc. If you can honestly say it has no chirps or clicks, then you have something. But compare it with clickless amplifier keying before you decide that it has no chirp.

Electrically, that's about all there is to the circuit. A linear condenser is used from the 2E26 plate to ground, to furnish a short return path for harmonics, and small resistors are used in series with the grids of the oscillator and output tubes, to discourage parasitics. Various extra by-pass condensers that crop up in the circuit were included because it was found that some harmonic energy was getting out on the power and control leads, and will undoubtedly vary with the construction. The complete circuit is shown in Fig. 3.

The switch, S_1, permits tuning the VFO to the frequency you want without putting a signal on the air. The 100-ohm resistor, R_{18}, is recommended by the relay manufacturer when the relay works in a circuit that is not purely resistive, and R_{17} is included just in case the drop through 100 ohms shifts the oscillator frequency appreciably. Terminals are provided in series with the relay winding for connection to a similar relay that shorts the receiver input and decreases the gain of the receiver, as described in the earlier article. As the proud owner of two of these relays the writer could afford to do this — most operators would mount the relay at the receiver, as described in the earlier article.[2]

If the exciter were built for 'phone work only, the 6SN7 control tube and the high-speed relay could be eliminated, of course.

Construction

Only general good practice was followed in the construction of the VFO, and no particular pains were taken to build it "like a battleship." However, it turned out to be rather insensitive to vibration and shows only the slightest trace of microphonics, and then only under rather severe conditions. Even so, it is set on a rubber kneeling pad on the operating table.

The unit is built on a 10 × 17 × 3 aluminum chassis, which is not very rigid by itself. However, an 8¾ × 11 panel of ⅛-inch dural, braced by the 5 × 5½ × 10 aluminum box surrounding the oscillator tuning section, adds strength and rigidity to the assembly, as does the chassis bottom plate. The oscillator tuning section determines the frequency — the effect of the tube is practically eliminated in the Clapp circuit — and everything

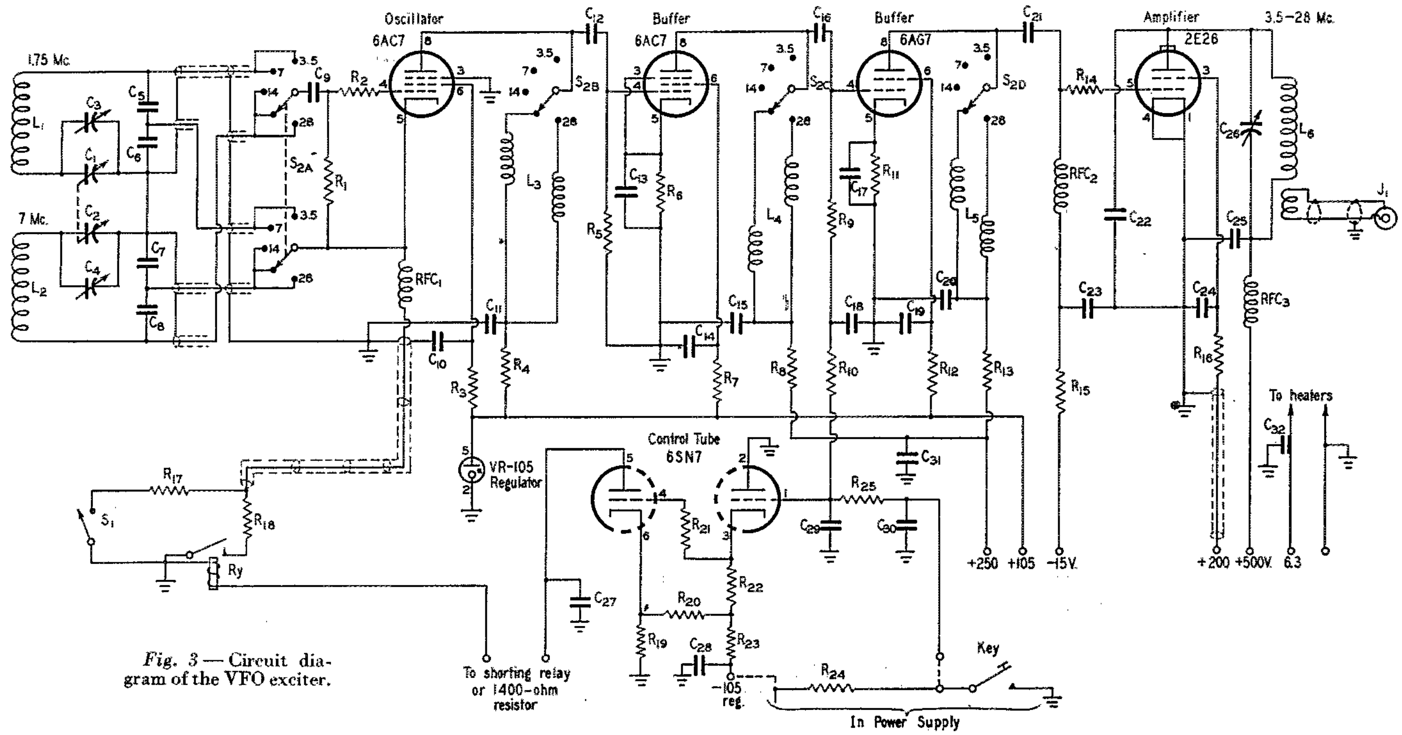


Fig. 3 — Circuit diagram of the VFO exciter.

C_1 — 9-plate midget variable.
C_2 — 2-plate midget variable.
C_1 and C_2 made by cutting down a Millen 21100.
C_3 — 50-μμfd. midget (Millen 26050).
C_4 — 100-μμfd. midget (Millen 26100).
C_5, C_6, C_7, C_8, C_{10} — 0.001-μfd. mica.
C_9, C_{12}, C_{16}, C_{21} — 100-μμfd. mica.
C_{11}, C_{13}, C_{14}, C_{15}, C_{17}, C_{18}, C_{19}, C_{20}, C_{23}, C_{24} — 680-μμfd. mica.
C_{22} — Linear condenser. See text.
C_{25} — 0.001-μfd. 1200-volt mica.
C_{26} — 100-μμfd. variable (Millen 22100).
C_{27}, C_{28}, C_{30}, C_{31} — 470-μμfd. mica.
C_{29} — 0.025-μfd. paper, 600 volts.
C_{32} — 0.1 μfd., 250 volts, special (Sprague "Hypass").
R_1 — 0.1 megohm.
R_2, R_{14} — 47 ohms, ½ watt.
R_3, R_7, R_{12}, R_{15} — 2200 ohms.
R_4, R_8, R_{10}, R_{11}, R_{13}, R_{16} — 330 ohms.
R_5, R_9 — 22,000 ohms.
R_6 — 680 ohms, ½ watt.
R_{17}, R_{18} — 100 ohms, ½ watt.
R_{19} — 17,500 ohms, 10 watts, wire-wound.
R_{20} — 3300 ohms.
R_{21}, R_{22} — 1.0 megohm.
R_{23} — 1500 ohms.
R_{24} — 3.3 megohms (in power supply).
R_{25} — 10,000 ohms.
All resistors composition and 1-watt unless otherwise specified.
L_1 — 75 μh. (National AR 16-160C, with 8 turns and center link removed).
L_2 — 9 μh. (Millen 43041, with one turn removed and used for leads).
L_3, L_4, L_5 — 3.5 Mc.: CTC LS3-1 Mc. with 95 turns removed.
— 7 Mc.: CTC LS3-5 Mc. with 16 turns removed.
— 14 Mc.: CTC LS3-10 Mc. with 4 turns removed.
— 21 Mc.: CTC LS3-10 Mc. with 11 turns removed.
— 28 Mc.: CTC LS3-10 Mc. with 14 turns removed.
L_6 — 3.5 Mc.: National AR16-40E shunted by 33-μμfd. mica, 4-turn link added.
— 7 Mc.: National AR16-20E.
— 14 Mc.: National AR16-20E, 7 turns removed.
— 21 Mc.: National AR16-10E, 4 turns removed.
— 28 Mc.: National AR16-6E, turns pushed together and 2-turn link added.
J_1 — Output cable fitting (Amphenol 83-1R).
RFC_1, RFC_3 — 2.5-mh. r.f. choke.
RFC_2 — 750-μh. r.f. choke (National R-33).
Ry — Fast relay (Stevens-Arnold "Millisec," 18 volts, 1400 ohms).
S_1 — S.p.s.t. switch.
S_2 — 4-section switch. Each section 2-pole, 5-position.

is tied down fairly well within the shield box. The coils are regular low-power transmitting coils mounted on heavy cone insulators, the tuning condenser is a double-bearing affair, and all leads are made with No. 12 or 14 wire. The tuning condenser was made by cutting a few stator plates out of a single-section condenser, to give a dual condenser of unequal-capacity sections. Two small end brackets that mount the tuning condenser to the chassis also support the padding condensers and the terminal boards that mount the large 0.001-μfd. condensers. The coaxial lines from these 0.001-μfd. condensers run out through rubber grommets, and the only chassis grounds in the oscillator circuits are back at the oscillator tube socket. We reasoned that it would be easier to keep the thing stable if the r.f. didn't wander all over the chassis looking for a way to get back to the oscillator tube. The tuning-condenser rotor is connected to the outer conductor of these coaxial lines and grounds only at the oscillator socket, not within the oscillator compartment. The tuning dial is, of course, insulated from the condenser shaft.

The remainder of the unit is built along the usual lines, with the possible exception of the output stage. At first, bandswitching of the output stage was considered, but we couldn't work out a simple clean-cut way and so had to settle for plug-in coils. The tuning condenser is mounted above the chassis, with the shaft projecting through a clearance hole. A large bakelite pulley on the shaft takes the string drive for controlling the condenser from the front of the panel. The panel control was made from the usual panel shaft assembly, with the string running over two small bakelite idler pulleys. Using string instead of a long extension shaft eliminates one possible source of over-all feed-back and takes up practically no room under the chassis. The two leads from the output plate coil go to the tuning condenser above the chassis, and the ground return from the tuning condenser runs through a ceramic bushing (Millen 32150) in the chassis to the plate blocking condenser. Here again we reasoned that it was better to know where the ground return path was than to depend upon the currents finding their way back to the cathode through multiple paths.

The linear condenser, C_{22}, was made from a length of ⅝-inch diameter copper tubing soldered to a small copper base plate. The inner conductor is supported by a National PRF-1 coil form, which slides over the tubing to a force fit after a little judicious use of steel wool on the end of the tubing. The inner conductor is a piece of ⅜-inch diameter dural rod, tapped at one end and rounded at the other. Anyone unfamiliar with these condensers can refer to page 21 of the April, 1949, issue of *QST* for a cross-sectional sketch of a similar one. The two cathode pins of the 2E26 are grounded through short copper straps.

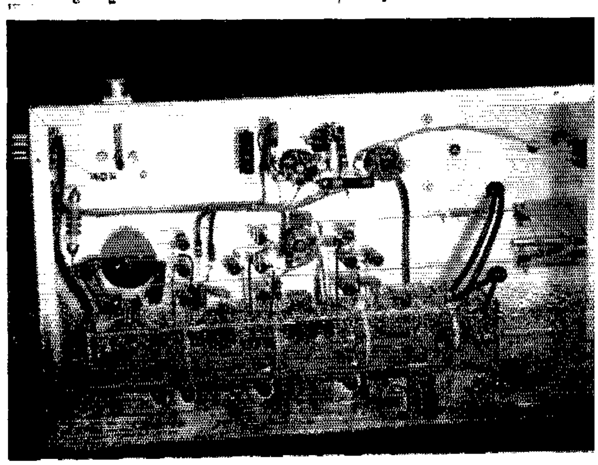
The band-change switch, S_2, is an extra-long one made from normal sections and parts, except for the shaft extension. Since the maximum length available is about 9 inches, we fashioned a longer one from a narrow slice of sheet dural. Although it is a little weaker than we like, it serves the purpose adequately.

Alignment

After the tuning range of the oscillator circuit is checked, the exciter is aligned on any band by switching to that band and setting the tuning dial in the center of the range. The fixed-tuned coils are all peaked for this frequency (as indicated by grid current measured across R_{15}, with screen and plate voltage off the 2E26). Then swing the tuning control to one end of the tuning range and repeak L_4, and then shoot down to the other end and peak L_3 on that frequency. Now as you tune across the range the grid current will vary somewhat (unless you're very lucky), but with a little judicious juggling you can get the grid current to vary not more than 1½-to-1 over the range. The grid current required is only 2 or 3 ma., and it's easy to get on the low-frequency ranges. At 28 Mc. you may have to squeeze a little, by peaking the thing for the c.w. (or 'phone) range only, and the excitation will be down compared with that obtainable on the other bands. This is one of those sad facts of life, but you can still get 12 or 15 watts output from the 2E26.

The final coils at L_6 are tailored to resonate at the low-frequency end of each band with C_{26} set at about 90 per cent of maximum. Yes, this is higher C than we're used to using at the higher frequencies, but it doesn't hurt the efficiency noticeably and it makes the thing very easy to load.

And there's the story. The gadget is ambitious for an inexperienced amateur to tackle, because the accent has been more on ideas than on details. However, it's a cinch for anyone who has built himself a few multitude gadgets and understands what the circuits are doing, and we think the reward for the work is more than adequate.



Removing the bottom plate shows the details of the string drive on the output tuning condenser and the arrangement of the components underneath the chassis.