Putting Dynamic Prognostication to Work

An Efficient, Compact, Flexible and Versatile Unit of Extreme Simplicity

BY LARSON E. RAPP, W1OU

> **The worth of this manuscript was immediately apparent to the editors when the story was first submitted for publication, and it was hurriedly scheduled for the very next issue of *QST*. There is no doubt that it should have a far-reaching effect on contemporary transmitter theory and design.**

Many developments in amateur radio are the result of insiduous experimentation or residual cut-and-try methods, while fewer and more outstanding ones are the end results of logical and clear-cut thinking. The unit to be described in this story should not be confused with either, because both methods were used to develop it.

The general trend towards simplification and versatility in amateur gear, along with compactness and efficiency, was the incentive for the author to follow the same general line of reasoning. Old methods were first discarded and then later brought into use, proving beyond a shadow of a doubt that if anything new was to be developed, the older reasoning must be eliminated. This was done by first building a breadboard model.

Circuit Development

Since most units in present practice employ at least three stages, the breadboard model was built with provision for a transmitter of at least three stages. The use of anything but beam-power tubes was never considered, not even for a minute, since the beam tubes are generally acknowledged to be the most efficient tube (from an economy and power-efficiency standpoint) available. Low-loss insulation was used throughout, and all shields were made of silver-plated copper. It was found later that the shields were unnecessary, so any experimenter verifying the results can save considerable money by dispensing with the shields from the start.

Although it has been said that grid neutralization makes a stage easier to drive than one with plate neutralization, it was found in these experiments that *no* neutralization made the stages still easier to drive, and neutralization was eliminated in all but the driver stage, which was later discarded. The elimination of neutralization should not be confused with the introduction of regeneration, as some authors have failed to point out.

With the elimination of neutralization and the consequent reduction in driving-power requirements, it was possible to eliminate the driver stage, leaving only the oscillator and final amplifier stages. The power from the crystal oscillator, although adequate to drive the final amplifier in an orthodox way, was not satisfactory from a dynamic standpoint, so it was decided to try regeneration through the screen circuit of the final amplifier, a method that has been wilfully neglected for years. To our great surprise, it was found that the screen feedback, through the capacity between the screen grid and control grid, not only gave the necessary regeneration and lowered drive requirements but also acted as a control-grid neutralizing circuit, resulting in high stability of the amplifier except at several points well outside the resonant frequency. This effect was found to be negligible when the stage was loaded. The grid-screen capacity of a metal 6L6 is too low for best results, but four out of five 6L6G's were found to be just right.

As a by-product of this lowered driving-power

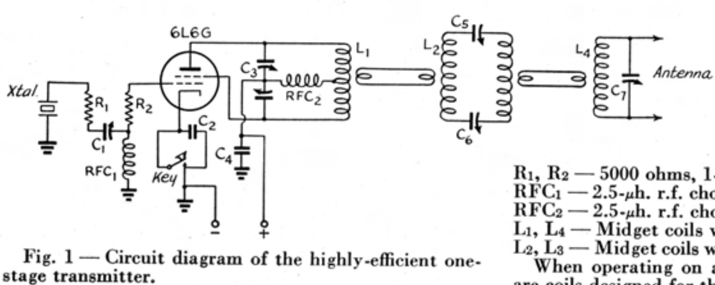


Fig. 1 — Circuit diagram of the highly-efficient one-stage transmitter.

C_1 — 35-$\mu\mu$fd. midget variable.

C_2, C_4 — 0.002-μfd. 800- volt paper.

C_3 — 140-$\mu\mu$fd. per section dual midget variable.

C_5, C_6, C_7 — 100-$\mu\mu$fd. midget variable.

R_1, R_2 — 5000 ohms, 1-watt.

RFC_1 — 2.5-μh. r.f. choke, 125 ma.

RFC_2 — 2.5-μh. r.f. choke, 250 ma.

L_1, L_4 — Midget coils with swinging links.

L_2, L_3 — Midget coils with fixed links.

When operating on any particular band, L_1 and L_4 are coils designed for that band and L_2 and L_3 are coils for the next higher-frequency band.

requirement, it was found possible to eliminate the crystal oscillator stage entirely, leaving only the crystal in the circuit for frequency control. Resistance coupling was employed between the crystal and the final amplifier stage, through the use of an inverted π-section filter. As can be seen in Fig. 1, R_1 and R_2 are the shunt elements of the filter and C_1 is the series element. RFC_1 is simply a d.c. return to ground and can be eliminated if the stage works better that way. Ours wouldn't work at all that way, and the choke was retained. The value of C_1 is adjusted for maximum drive with minimum crystal heating.

The next step in the development of the circuit was the antenna coupling, the bugaboo of most high-efficiency installations. Link coupling was found to be the most efficient, confirming the findings of other experimenters, so it was decided to try "double" link coupling. This was found to be a great improvement, and it is surprising that it hasn't been used before this. The final circuit, as shown in Fig. 1, results in no coupling back from the antenna to the transmitter when C_5 and C_6 are properly balanced, and consequently a swinging antenna has no effect on the transmitter frequency.

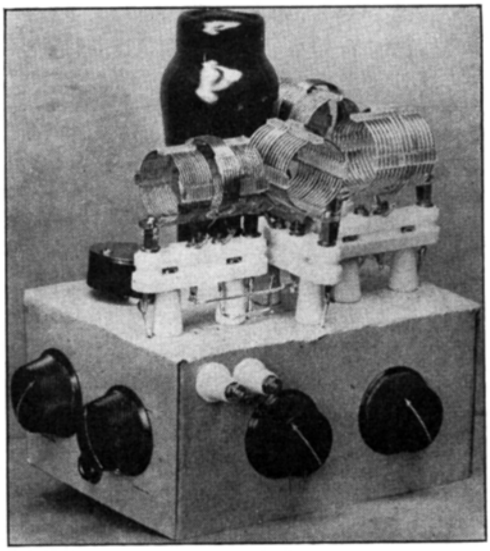
Keying was the next problem to be attacked and, after trying all circuits and discarding them, the symmetrical circuit shown in Fig. 1 was evolved. Apparently the symmetry of the circuit gives a very good waveform, and the resultant "click" (sometimes called "thump") is almost negligible. Possibly by using a twin beam-power tube having separate cathode connections, a split-stator condenser for C2 and a twin key could be used for perfect symmetry and consequent perfect keying.[1]

The rest of the circuit is conventional and represents present practice.

Construction

The finished model, shown in the photographs, represents several innovations in amateur practice. Some months back a conductive, or "low-resistance," rubber was announced secretly to the trade. This would make an ideal chassis material, since it combines shock-absorbing characteristics with extreme flexibility. However, since it is not yet available through regular channels, we went to the next best thing and built the chassis of semi-stiff cardboard covered on the underside with tin foil. Copper foil would be better but it was not available at the time. Cardboard has the virtue that it can be easily drilled, requiring nothing more than an ice pick and a pair of manicure scissors to work it. Although it is not as flexible as rubber, it is readily bent and can be glued or pasted together. Minor mistakes in the placement of holes can be easily corrected.

[1] — Mr. Rapp is slightly in error here. It is not necessary to have a completely symmetrical waveform for perfect keying, as long as the well-known relation $C_2 = \frac{E}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$ is satisfied. — Ed.



A compact transmitter of high efficiency and simplicity. The tuning controls at the front are crystal coupling and antenna output, with the key jack mounted between. The knobs on the side by the antenna terminals control the antenna coupling condensers, and the plate tuning condenser is turned by a knob on the far side in back of the tube.

Note the simple construction of the chassis which is made from cardboard fastened by wire staples and glue. The underside is covered with tin foil.

As can be seen from the photographs, the finished model is rather compact. This could have been carried further, except for the odd shapes of some of the components. However, the air spaces between some of the pieces of gear are not really necessary, since the high efficiency of the unit results in very little heat being radiated, most of it staying within the tube where it is more available. Purists who worry about mounting the coils so close to each other can be assured that the incidental neutralizing between control and screen grid, together with the tight coupling possible through the "double link" system, results in practically no external field.

Tuning

Tuning is more or less conventional, except that care must be exercised in tuning with no load. The high coupling efficiency of the unit results in a minimum plate current at resonance of about 0.9 ma. at 7 Mc. This is too low a value to show on the 0–250 milliammeter that should be used in the circuit, so you'll have to take our word for it.

As the antenna coupling is critical, with two tuned circuits and the double link coupling, two hands should be used for tuning, particularly for beginners. With 900 volts on the plate, the normal

(Continued on page 94)

Dynamic Prognostication

(*Continued from page 31*)

current will run around 240 ma., for several seconds.

The measured efficiency, with a new 6L6G in the socket and 700 volts on the plate, was 94.3 per cent from crystal to antenna. This includes the screen current which contributes no power to the antenna, so it can be seen that the efficiency is quite high. If it later becomes possible to manufacture a triode with beam-power advantages, the screen power will be eliminated and the efficiency boosted still higher.

Performance and Versatility

It had been hoped that the unit would be versatile enough to be used in several ways. Actually, it can be used for reception by plugging in a pair of headphones where the key normally goes. Since the plate current passes through the cathode circuit, a plate detector is formed and, by unbalancing C_5 or C_6 (but not both), energy can get from the antenna into the plate circuit to allow the tube to function as a plate detector. The current through the cathode circuit is high, however, and a coupling transformer should be used, to avoid burning out the headphones. It must be confessed that the unit is not as efficient a receiver as it is a transmitter, and no real DX was heard during several nights of listening on the 7- and 14-Mc. bands. This may be caused by the inadvertent band-pass effect of the antenna coupling system, or some other reason beyond our control. It is, however, a condition that we hope will clear up in the very near future.

Strays

The magnet from an old meter placed at the spot where a hole is to be drilled in the chassis will keep the chips from falling to the floor. A home-made electromagnet will work even better. — *W8OSI.*

—···—

W9QLC tells what direction his beam antenna is pointed by using a large mirror adjusted to the right angle just outside his shack window. By painting the rotating portion white, it shows up very nicely in darkness.

—···—

W2EXQ has automobile license-plate number FB73K.

—···—

Having a message for the N.H. Net, I turned on the receiver and tuned to the frequency of W1GMM. The first thing I heard was, "CQ de W2GMM." — *W1IIE.*

—···—

Changed my keying leads of ordinary wire to 20 ft. of shielded mike wire and cleared up b.c. interference entirely. Cannot hear the rig on b.c. receiver in the same house. — *W6SUD.*

—···—

Heard a W9 calling like this: "CQ CQ CQ Urgent de NVER." Careful listening disclosed that he wanted Denver! — *W3QP.*