An Inexpensive Two-Stage Three-Band Transmitter

150-Watts CW Output with the 815

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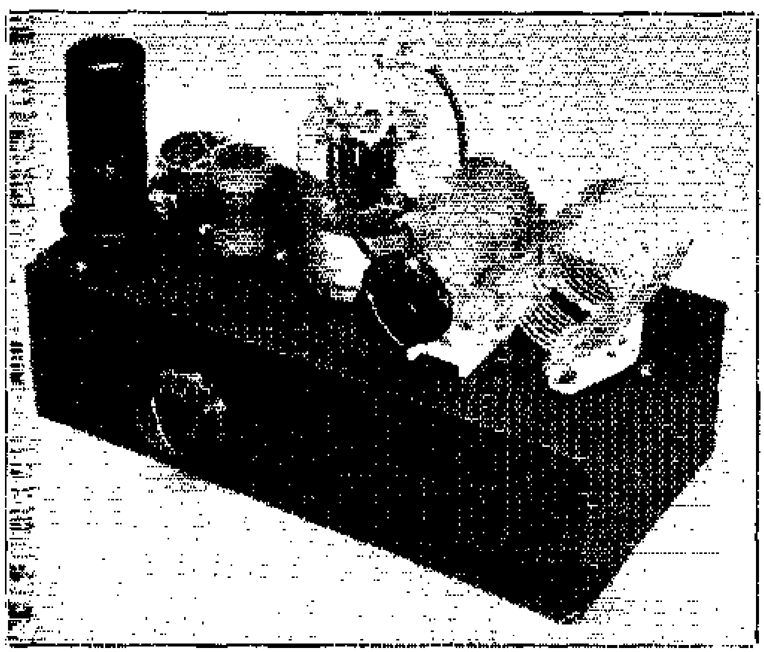
This is a low-power CW transmitter with simple and compact construction, ease of operation, and inexpensiveness for the recently developed Type 815 double beam tube.
Although this tube has been talked about mostly for ultra-high-frequency work, its obvious advantages — high-power sensitivity, push-pull operation, no neutralization, and low-voltage operation certainly are attractive on the lower frequencies too.



Front view of the transmitter. Construction is compact without undue crowding of the components.

The design is a transmitter having only two stages, and capable of working in three bands from one crystal, because the 815's excitation requirements are so low.

Fig. 1 shows the circuit diagram of the transmitter.

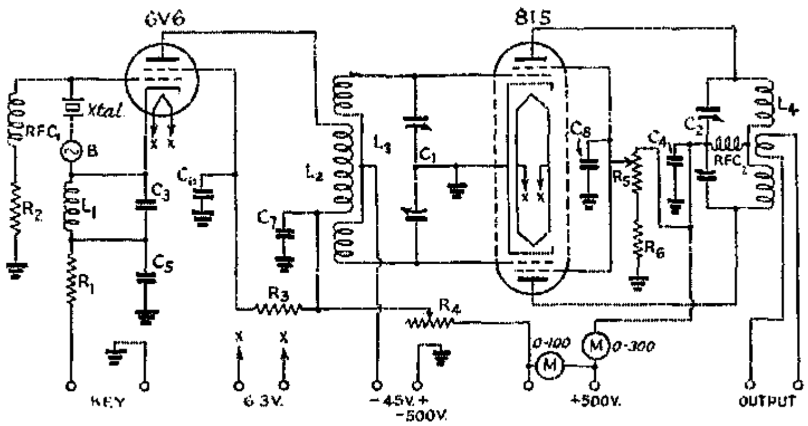


Fig. 1 **— Circuit diagram of the 75-watt transmitter.**
C_1 — 140-μμfd. per section dual midget variable (Hammarlund HFD-140).
C_2 — 140-μμfd. per section dual midget variable (Hammarlund MCD-140-M).
C_3 — 200-μμfd. mica.
C_4 — 0.005-μfd. paper, 1600-volt rating.
C_5, C_6, C_7, C_8 — 0.01-μfd. paper, 600-volt rating.
R_1 — 200 ohms, ½-watt.
R_2 — 20,000 ohms, 1-watt.
R_3 — 20,000 ohms, 10-watt.
R_4 — 6000 ohms, 25-watt.
R_5, R_6 — 5000 ohms, 25-watt.
RFC_1 — 2.5-mh. r.f. choke (National R-100).
RFC_2 — 1-mh. r.f. choke (National R-300).
B — 60-ma. lamp.
L_4 — 21 turns No. 24 d.s.c., close-wound, ½-inch diam.
(See Fig. 2 for specifications of L_2 and L_3.)

A Tri-tet oscillator is used so that driving power can be obtained for the amplifier on three bands from one crystal. Since the efficiency of a crystal oscillator delivering fourth-harmonic output is comparatively low, a 6L6 is used as the oscillator tube so that the necessary driving power can be obtained without excessive dissipation. Because only 3.5-MHz crystals are used, a fixed-tuned cathode circuit may be used in the oscillator. This eliminates the cost of one variable condenser but also reduces the number of controls.

The problem of coupling between the single-ended oscillator and the push-pull 815 grids was solved by the arrangement shown in the diagram.

Two other methods might have been used:

- Capacity coupling with a tapped tank -
  Not altogether satisfactory because the driving tube is connected across only half of the circuit and therefore introduces some unbalance.

or,

- Ordinary link coupling:
  Requires two tuned circuits, which is neither economical nor convenient.

The circuit shown consists of a balanced grid tank closely coupled to an untuned plate winding and resembles the RF transformers used in receiver circuits. Besides requiring only one tuning control, this method has the additional advantage that the amount of power fed to the 815 is readily controlled by the number of turns on the plate or primary winding, L_2. This is important in a setup

of this type, since at the crystal fundamental and second harmonic the driving power available is far more than the optimum for the tube, and some means must be provided for reducing it if over-excitation (with consequent heating of the screen and loss of power output) is to be avoided.
In practice, the size of L_2 is adjusted so that somewhat more than the rated grid current (approximately 4 mA under the chosen operating conditions) is available, and fine adjustment is secured by detuning C_1 slightly from exact resonance.

With oscillator keying, some method must be used to hold down the plate current of the amplifier when the key is up and there is no excitation. Fixed bias is the simplest method, and works out nicely in the present case since the operating bias required by the 815 in CW work is only 45 volts. A single 45-volt “B” block is convenient and costs comparatively little.

Construction
The front-view photograph shows how the main parts are mounted on a chassis measuring 3 by 5 by 10 inches.

- The 815 is centered between the front and rear edges, 5.25 inches in from the right-hand end.
- The octal tube socket should be mounted with pins numbers 1 and 8 pointing toward the left-hand edge of the chassis; this allows the grid connections to be short and direct.
- Sockets for the 6L6, the 60-mA bulb and the crystal are mounted in a line parallel with the left edge of the base. Note: the schematic shows this tube to be a 6V6. I am not certain how to deal with discrepancy. There does not appear to be any corrections in subsequent issues of *QST*.
- A socket for L_2-L_3 is centered 2.625 inches in from the left edge.
- C_2 and L_4 occupy the space between the 815 and the right end of the chassis.

C_2 can be easily mounted by removing the small shield between the two sections so that a 6—32 machine screw may be slipped through the hole through which the lug passed, and the condenser bolted to the chassis. <u>This method provides the insulated mounting which is essential to the type of circuit connection used.</u>

The bottom view of the transmitter shows the arrangement of the components mounted below the chassis. All leads running to and from the unit terminate at the 10-terminal strip centered on the rear wall of the base.

Although the circuit diagram shows the screen and plate returns of the 815 connected to a common terminal, it would probably be better to use a separate terminal for the screen circuit so that a milliammeter may be connected in the plate circuit alone. This will avoid the necessity for deducting the current flowing to the screen and its voltage divider from the reading of a meter in the "B" supply lead in order to obtain the plate current.

The cathode coil is held firmly in place by the cathode condenser with which it is in parallel.

C_1 is mounted on the front wall of the chassis and has its shaft centered 3.375-inches from the oscillator end.

The rest of the parts may be laid out in a convenient arrangement, keeping the RF leads as short as possible.

Important - Concerning the construction of the cathode coil:

> A sheet of paper should first be wrapped around a 0.75-inch diameter form. The 21 turns of wire are then wound over the paper and are given a coat of Duco cement or coil-dope. Don't attempt to wind the coil without using the layer of paper, because the winding will stick to the form and the two will be difficult to separate.

Operation

Test the oscillator circuit first.

1. The plate and screen voltages are removed from the 815 during this period.
2. With voltage applied to the oscillator, the 815-grid circuit, C_1L_3, should be brought to resonance as indicated by maximum reading on a milliammeter connected in the amplifier grid-bias lead.
3. The dropping resistor, R_4, should be set at its full value of 6000 ohms during the preliminary testing; to secure proper plate voltage, a final setting may be made when the power supply is completely loaded by the entire transmitter.
4. The grid current should be in the neighborhood of 10 milliamperes on all three hands. The oscillator plate current will remain almost constant during this tuning, because relatively little power is taken from the oscillator circuit.

After the oscillator has been checked, the amplifier may be put into operation.

1. The screen voltage lead should be tapped in-between the two 5000-ohm resistors, R_5 and R_6. This reduces the voltage applied to the screen grid and thus provides a safety factor during the preliminary tests.

2. With plate voltage and grid excitation applied, the off-resonance plate current should be 250 milliamperes or so, dropping to approximately 25 milliamperes with the plate circuit tuned to resonance.
3. A dummy load should now be connected to the final tank circuit and the coupling adjusted (it may be necessary to wind a loop of several turns around the tank coil to obtain proper coupling) to bring the on-resonance plate current to 150 milliamperes.
4. Oscillator plate and amplifier screen-grid voltages may then be adjusted to 300 and 200 volts, respectively, by adjusting the taps on the two dropping resistors.

It is probable that the amplifier plate current will either rise or fall at this point, depending upon whether the oscillator circuit and the 815 screen grid take more or less power than they did before. If the plate-current change is considerable it will be wise to reset the final load and then make another check of the various voltages.

With all voltages at the proper values the various currents will be about as follows:

- Oscillator plate, 40 milliamperes;
- 815 grid, 4 or 5 milliamperes;
- 815 plate, 150 milliamperes.

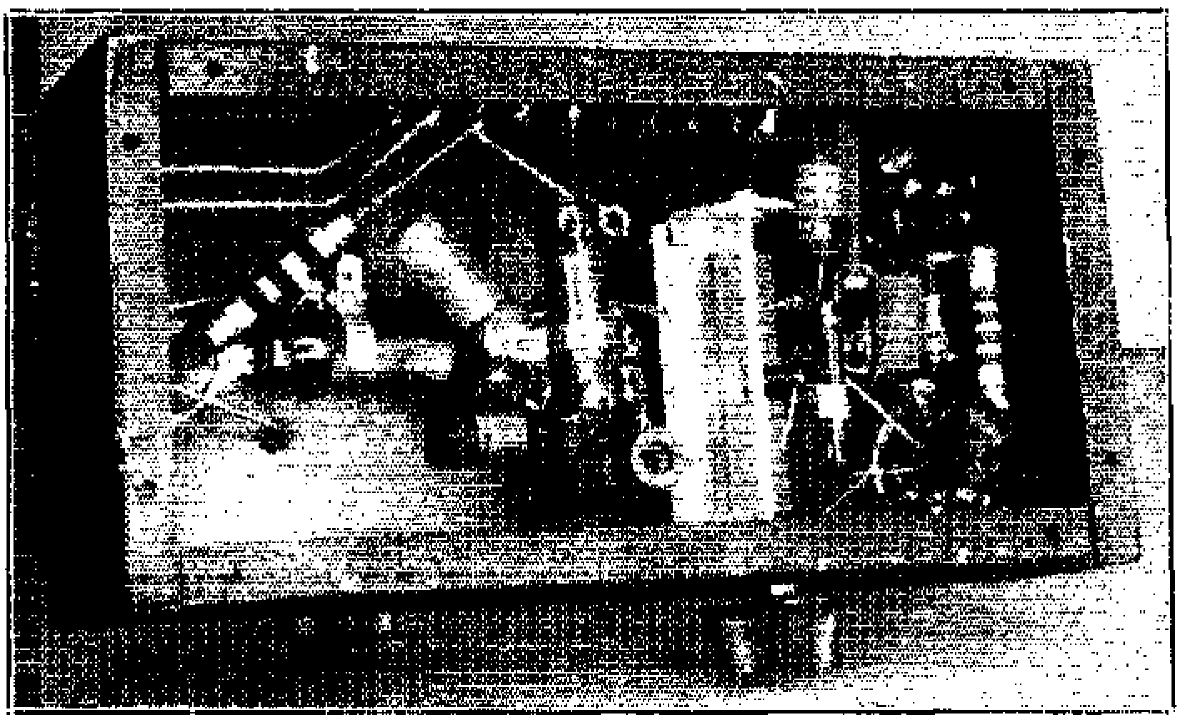
It will be found that a grid current of 4 to 6 milliamperes gives the best output and that more grid current fails to increase either the output or efficiency.

A meter inserted in the amplifier's screen-grid circuit should show a current of 60 milliamperes; about four-fifths of this is taken by the voltage divider.

When the transmitter is in actual operation it may be observed that the amplifier plate current does not fall to complete cut-off when the excitation is removed. This is to be expected unless the power supply has such excellent regulation as to prevent any considerable increase in screen voltage when the load is greatly reduced. However, the plate current should drop to only a few milliamperes as long as the screen voltage does not reach a value exceeding the normal 200 volts by more than 50 or 75 volts.

There is another reason why it is important to have good screen-voltage regulation. Should the amplifier be operated without a plate load, there is a possibility that self-oscillation will take place on the higher-frequency bands when the screen voltage goes above normal. This is because under these conditions the tube's power sensitivity increases and stray feedback is maximal. Of course the transmitter is not normally worked without a load, and with normal loading there is practically no danger of self-oscillation, but it is just as well to make the outfit as stable as possible under conditions likely to be encountered only accidentally.

The amplifier plate coils are complete with links which permit working directly into a low impedance line. This means the amplifier may be fed into low impedance (73-ohm) antenna feeders or that it may be linked coupled to an amplifier operating at higher input.
An antenna tuner is needed for a system employing a high-impedance feed line.



A bottom view of the transmitter. The fixed cathode coil may be seen at the lower right-hand corner. The variable condenser, C_1, is tipped slightly so its frame will clear the tube socket mounted above.

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