807s in Push-Pull

A Shielded Stabilized Rig for the Low-Frequency Bands

BY DONALD H. MIX,* W1TS

• *Highlighted on this month's cover,* the transmitter described in this article *represents application of the points discussed in the June issue in regard to* transmitter stability.[1] When initially adjusted as described in detail in that article, the rig is entirely free of instability of any kind, with or without load. The enclosed construction and use of harmonic filters are measures taken to reduce TVI.

In the mind, at least, 807s and other transmitter-type screen-grid tubes usually are associated with simplification of circuit. Therefore, it is natural that when a pair of such tubes is used, the two are most often connected in parallel, rather than in push-pull, since the parallel connection requires no departure from the simple circuits that are adaptable to single tubes. However, there are those who always insist on push-pull in the output stage, and it is true that, for the same tank-circuit Q, the losses should be somewhat less with push-pull because the tank current is less with the higher L/C ratio which push-pull permits. As a matter of fact, if the stage is to be neutralized, as seems advisable for reliable stability,[1] the push-pull arrangement adds little if any complication.

While any of a number of combinations might be used as the exciter for a pair of 807s, that shown in Fig. 1 is one logical result of certain considerations. The comparatively-low power-handling capabilities of the small present-day crystals have presented somewhat of a problem in postwar ham transmitters. You can't get 10 or 15 watts from the oscillator as we were accustomed to in prewar days and still keep the crystal in one piece. The modified Pierce oscillator circuit using a 6AG7 was chosen because it is the simplest of the crystal circuits capable of harmonic as well as fundamental-frequency output. The Tri-tet and grid-plate circuits require cathode-circuit tuning which is not always easily adjusted. However, the output from the Pierce arrangement is insufficient to drive a power doubler with good efficiency if the screen voltage is to be limited to prevent excessive crystal current. Therefore it is desirable to follow the oscillator with a stage that can be operated safely at low efficiency, if necessary, without exceeding the dissipation rating.

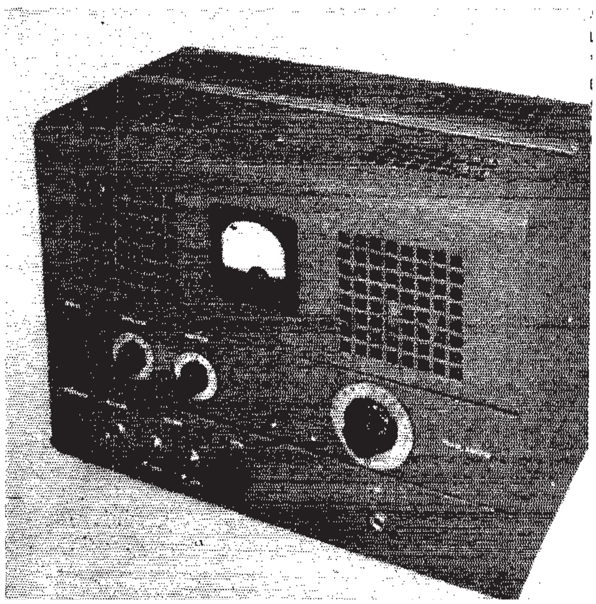
The pair of 6V6s may seem like a large driver for a couple of 807s, but they operate well under rating, even when doubling to 28 Mc. The push-pull arrangement provides not only the desirable "pick-up" in output when doubling, but also automatic neutralizing when the heater of one of the two tubes is turned off while the other is working straight through on bands not requiring doubling. Both the oscillator and buffer operate from a single 325- to 350-volt plate supply. The buffer as well as the oscillator is keyed so that no protective bias need be provided for this stage.

Experience has shown that it is preferable to switch both sides of the crystal in this oscillator circuit, since neither side is grounded, and trouble may be encountered if a single common lead ties one side of all crystals together. The output tank circuit, L_1C_6, is split by the dual-section condenser to provide push-pull input for the 6V6s. C_7 is a balancing condenser to compensate for the output capacitance of the 6AG7 which appears across the opposite side of the tank circuit. RFC_1 and RFC_2 are parallel-feed chokes. A separate voltage divider, R_2R_3, supplies 100 volts for the screen of the oscillator.

The output circuit of the buffer stage, L_2C_{14}, also is split to provide push-pull input to the final stage. C_{15} is a balancing condenser whose purpose is similar to that of C_7. Series grid feed and

* Assistant Technical Editor, *QST*.

[1] Mix, "Amplifier Instability in Transmitters," *QST*, June, 1948, p. 19.



Front view of the push-pull 807 transmitter showing the arrangement of controls.

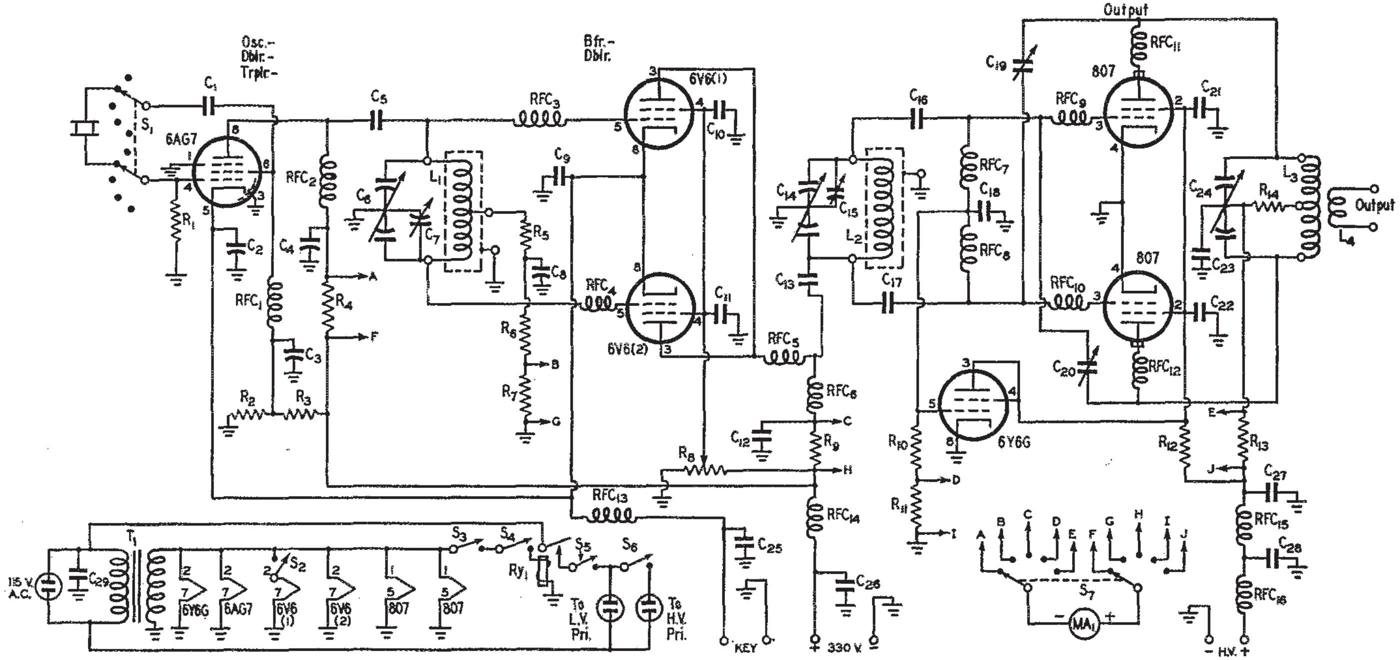


Fig. 1 — Circuit diagram of the push-pull 807 rig.

C_1, C_5, C_9, C_{10}, C_{11}, C_{12}, C_{13}, C_{18}, C_{25} — 0.0015-μfd. mica.
C_2, C_3, C_4, C_8 — 0.01-μfd. paper.
C_6, C_{14} — 100-μμfd.-per-section variable (Hammarlund HFD100).
C_7 — 30-μμfd. mica trimmer.
C_{15} — 50-μμfd. variable (Hammarlund HF50).
C_{16}, C_{17} — 47-μμfd. mica.
C_{19}, C_{20} — Neutralizing condensers (see text).
C_{21}, C_{22} — 0.0047-μfd. mica.
C_{23} — 0.001-μfd. 5000-volt mica.
C_{24} — 190-μμfd.-per-section variable, 0.05-inch plate spacing (Cardwell MO-180 BD).
C_{26}, C_{28}, C_{29} — 470-μμfd. mica.
C_{27} — 220-μμfd. mica.
R_1 — 12,000 ohms, ½ watt.
R_2 — 10,000 ohms, 1 watt.
R_3 — 20,000 ohms, 2 watts.
R_4, R_5, R_7, R_{11} — 220 ohms, 1 watt.
R_6 — 82,000 ohms, ½ watt.
R_8 — 25,000-ohm 7-watt potentiometer.
R_9 — Four-times shunt, wound with No. 30 copper wire.
R_{10} — 11,200 ohms, 2 watts.
R_{12} — 25,000 ohms, 10 watts.
R_{13} — 10-times shunt, wound with No. 30 copper wire.
R_{14} — 100 ohms, 5 watts.
L_1 — 3.5 Mc. — 50 turns No. 24 d.s.c., close-wound.
7 Mc. — 26 turns No. 24, 1¼ inches long.
14 Mc. — 16 turns No. 22, 1¼ inches long.
21 Mc. — 10 turns No. 22, 1¼ inches long.
All above coils are tapped at the center; 1-inch diam.
L_2 — 3.5 Mc. — 36 turns No. 24 d.s.c., close-wound.
7 Mc. — 20 turns No. 24, 1¼ inches long.
14 Mc. — 12 turns No. 22, 1¼ inches long.
21 Mc. — 8 turns No. 22, 1¼ inches long.
28 Mc. — 6 turns No. 18, 1 inch long.
All above coils are 1-inch diameter.
L_3 — 3.5 Mc. — 34 turns No. 16.
7 Mc. — 20 turns No. 16.
14 Mc. — 12 turns No. 14.
21–28 Mc. — 6 turns No. 14.
All above coils are 1⅞ inches diameter.
L_4 — Link-coupling coil to suit requirements.
MA_1 — 25-ma. d.c. meter.
RFC_1, RFC_2, RFC_6, RFC_7, RFC_8 — 2.5-mh. r.f. choke.
RFC_3, RFC_4, RFC_5, RFC_9, RFC_{10}, RFC_{11}, RFC_{12} — V.h.f. parasitic choke, 15 turns No. 20 d.s.c., ¼-inch diam., close-wound.
RFC_{13}, RFC_{14}, RFC_{16} — Ohmite Z-1 r.f. choke.
RFC_{15} — Ohmite Z-0 r.f. choke.
Ry_1 — 6.3-volt a.c. relay, 5-amp. contacts.
S_1 — 2-section ceramic rotary switch.
S_2, S_5, S_6 — S.p.s.t. toggle switch.
S_3, S_4 — Interlock switches (see text).
S_7 — 2-section bakelite rotary switch.
T_1—6.3 volts, 5 amp.

parallel plate feed are used in the buffer. Bias is furnished by the grid leak, R_6. Screen voltage for the 6V6s is taken from a potentiometer, R_8, which serves as an excitation control for the 807s. RFC_3, RFC_4 and RFC_5 are v.h.f. parasitic chokes.[1]

Capacitance coupling is used between the driver and final stages. As Fig. 1 shows, neutralization is introduced in this stage rather than depend upon loading as the stabilizer. Parallel grid-bias feed is employed here because direct coupling to the driver, without the coupling condensers, C_{16} and C_{17}, overloads the driver stage. The plate circuit is series fed, and screen voltage is obtained from the plate supply through the voltage-dropping resistor, R_{12}. RFC_9, RFC_{10}, RFC_{11} and RFC_{12} are v.h.f. parasitic suppressors.

The 6Y6G is a protective device to limit the input to the 807s to a safe value when excitation is removed. So long as grid current flows to the final, the bias developed across the grid leak, R_{10}, which is applied to the grid of the 6Y6G as well as to the 807 grids, is sufficient to cut off the plate current of the 6Y6G and therefore it has no effect upon the operation of the amplifier. However, when excitation is removed, the bias falls to zero and the 6Y6G draws considerable current through R_{12}, reducing the 807 screen voltage to the point where the input falls to between 50 and 70 ma. with a 750-volt supply.

Care has been taken in designing the circuit to avoid setting up conditions favorable to low-frequency parasitics.[1] Because parallel grid feed in the output stage is desirable in this case, R_{14} is used in preference to the customary r.f. choke at this point. Low-frequency oscillation in the driver stage is eliminated by the introduction of R_5, by-passed by C_8 in the grid circuit, which places a heavy load on the parasitic grid circuit but not across the normal operating circuit.

Both plate-supply leads as well as the key lead are provided with harmonic filters to reduce the possibility of TVI. A two-section filter is required in the high-voltage lead. The milliammeter is switched across the metering resistors R_4, R_7, R_9, R_{11} and R_{13} to read oscillator plate current, buffer grid or plate current, and final-amplifier grid or plate current. The shunts in the oscillator plate and the buffer and final-amplifier grid leads are sufficiently high in resistance to have no practical effect upon the meter reading. However, R_9 is adjusted to multiply the scale reading by four and R_{13} is a multiplier of ten.

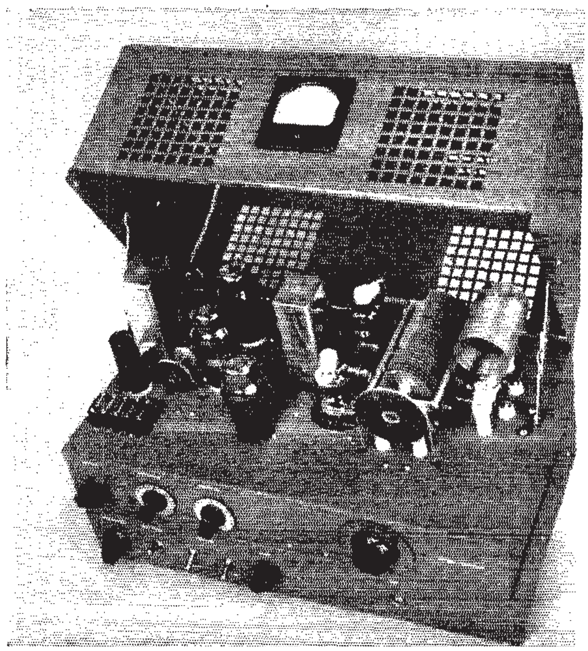
A control system is included so that the two plate supplies can be turned on and off from the transmitter panel by S_5 and S_6. The plate-transformer primaries are connected into the system through a.c. outlets at the rear of the transmitter enclosure. S_3 and S_4 are safety-interlock switches controlling the relay, R_{y1}. They operate whenever the transmitter enclosure is opened. If either of these switches is not closed, the plate supplies cannot be turned on. S_2 controls the heater of 6V6 (1) which is not used when the buffer stage operates straight through.

Construction

Aside from the factor of appearance, the completely-enclosed construction provides safety in operation and shielding against direct radiation of harmonics. A standard 10 × 17 × 3-inch amplifier foundation makes up the two top sections. A second chassis is used inverted as a bottom deck to house the control equipment, harmonic filters, the filament transformer, etc. It also permits hinging the transmitter proper for easy inspection or servicing. The top cover is hinged too, so that it may be swung open quickly for changing plug-in coils. Piano hinges extending the full length of the chassis make a good solid job.

The components on the upper deck are laid out to provide as much isolation as possible between input and output circuits. Thus the first and last tank condensers appear above the chassis, while the middle one is mounted below. The two exciter coils, both of which are on top for convenience in changing bands, are mounted in shielded plug-in units. The 807 sockets are submounted to bring the lower edge of the internal shields of the tubes level with the chassis. The sockets are fastened to a 2½-inch strip of aluminum spanning the bottom of the chassis. This strip is braced between the sockets by a metal spacing pillar running between the strip and the chassis.

Because of the hinged cover, all tuning controls must be brought out below the top of the chassis. In the case of the two tuning condensers that are mounted on top, the shafts are operated from controls below by means of pulleys. The ones shown in the photographs were made



The hinged cover opens for coil changing. The tube near the center is the 6Y6G protective tube.

from thumb dials taken from surplus equipment, but any standard dial drum which fits a ¼-inch shaft can be used, of course. A larger pair was used for the final tank condenser with the idea of reducing cord slipping, but it was found necessary to anchor the cord to the pulleys anyway, so the large size has no particular advantage.

Care should be used to keep parts on top of the chassis back far enough so as not to interfere with opening and closing of the cover. The crystal switch and sockets are grouped together at the left-hand end of the chassis, close to the front where they are readily accessible. There is room for several more crystals than the five shown, if desired. To the rear of the crystals are the 6AG7 and its output tank circuit with the 6V6s close to the tuning condenser, C_6, which is mounted directly on the chassis. The parasitic chokes, RFC_3 and RFC_4, are mounted in grommets set in the chassis alongside C_6, forming the connection between the stators of C_6 and the grids of the 6V6s. The compensating condenser, C_7, is supported underneath at the L_1 coil socket, between the prong that connects to the proper end of the coil and the prong that grounds the shield.

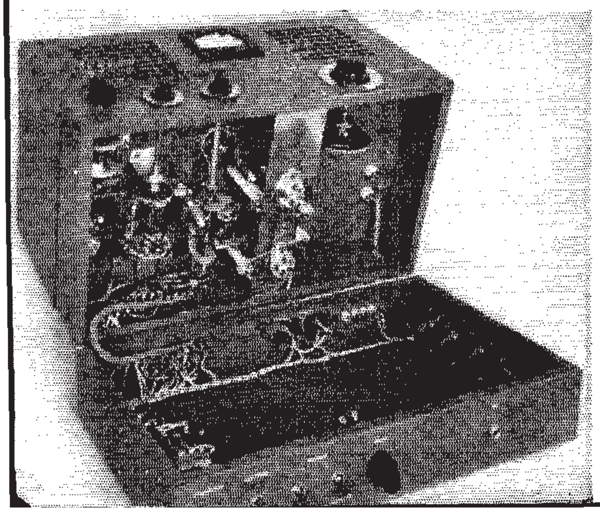
Underneath, the buffer tank condenser, C_{14}, is mounted on metal spacers to bring its shaft in line with the shaft of the crystal switch. The aluminum-strip bracket that supports the bearing for the tuning control for C_6 is then moved around until the shaft is central and in line between the shafts of the crystal switch and C_{14}. This flexibility in positioning of the control is another advantage of the pulley arrangement, incidentally. Holes are drilled in the chassis for the string connecting the two pulleys.

The balancing condenser, C_{15}, is mounted close to the right of C_{14} with its shaft pointing toward the rear so that it may be adjusted with a screwdriver through a hole from the back. National 2½-inch isolantite pillars (GS-2) are used as supports and junction points for RFC_7, RFC_8, RFC_9, RFC_{10}, C_{16}, C_{17} and the neutralizing leads. The neutralizing condensers, C_{19} and C_{20}, are made first by twisting the wire conductors out of a pair of National TPB polystyrene feed-through bushings. The holes are drilled out with a No. 35 drill and tapped for 6-32 machine screws. The bushings are then set in the chassis close to the central stator terminals of the plate tank condenser, C_{24}. Flat-head 6-32 screws, 2 inches long, are threaded into the bushings, the flat heads serving as the movable plates of the neutralizing condensers. A slot is cut in the end of the screws so that they may be adjusted with a screwdriver from the top. Connections are made by means of a soldering lug under a locking nut on top of the bushing. The necessary crossover connection is made above the chassis between the neutralizing condensers and the tank-condenser stator sections. The stationary plates of the neutralizing condensers are ½-inch washers (the top washers from the GS-2 insulators) mounted on ½-inch feed-through insulators set in the aluminum strip holding the 807 sockets.

The final-amplifier plate tank condenser is insulated from the chassis on ¾-inch cone pillars at all of the four corners except the left rear. Here a feed-through insulator, topped by a spacing washer of proper thickness, is used to provide a means of feeding the high-voltage line to the rotor of the tank condenser. C_{23} is placed immediately below, fastening it to the rear inside edge of the chassis on a metal spacer at its ground side. The link output is brought down through the chassis on feed-through insulators and then to a coaxial fitting at the rear.

All power terminations from the upper chassis are brought to a terminal board at the left. This terminal board is duplicated in the lower chassis and the corresponding points tied together through a cable, thus bridging the hinge. Along the front edge of the lower chassis, from left to right, are the excitation control, R_8, the doubler switch S_2, the plate-supply switches, S_5 and S_6, the meter switch, S_7, and the key jack. The filament transformer and the safety-interlock relay, Ry_1, are fastened along the left-hand edge. One of the interlock switches, S_4, is mounted in the front left-hand corner. It is made from the "works" of a leaf-type open-circuit jack. When the upper chassis is closed, the jack is closed by a small cone insulator fastened to the side of the upper chassis just below the crystal switch. Both sides of this jack must be insulated. The other interlock switch operates when the cover is raised and lowered. A long screw projecting on the inside of the cover at the rear makes contact with a leaf from a 'phone jack mounted on a stand-off insulator in the rear left-hand corner of the upper chassis. Thus both the cover and the upper chassis must be shut, closing the relay, before the power-supply switches will operate.

The power-input plug for the 115-volt line is at the left-rear corner of the lower chassis, below the terminal board. C_{29} by-passes the ungrounded



Bottom view showing the components located under the top deck.

side of the line to the chassis. To the right are the two outlets for the high- and low-voltage transformer primaries. D.c. input connections from the power supplies are made at the Millen terminal strip and safety terminal at the right. Components of the harmonic filters are mounted on a terminal board fastened to the right-hand edge of the chassis. The meter is connected to the switch by means of long cabled flexible leads passing to the terminal board through a rubber grommet in the rear left corner of the upper chassis. The metering resistors are mounted directly on the switch.

Coils

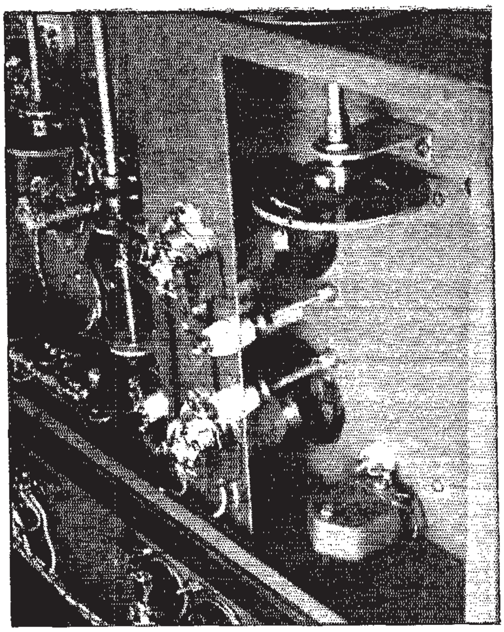
The exciter coils are wound on Millen 1-inch bakelite forms mounted in Millen octal-base shielded plug-in units, Type 64400. The forms are fastened to the base with a machine screw after drilling and tapping the octal base at the center through the locating plug. The shield can is wired to one of the prongs so that it is connected to ground when the unit is plugged in.

The output-stage tank coils are wound on Millen 44001 polystyrene forms. The link winding, L_4, is wound with No. 14 wire covered with small spaghetti, on a diameter which will fit inside the Millen coil form where it is centered and fastened with Duco cement. On the higher-frequency coils, the link leads may be brought out between the turns of the tank coil near the center. But on the lower-frequency coils, where the turns are too close together, it is necessary to bring the leads out through the ends of the form.

Adjustment

Eighty-meter output is obtained, of course, with a 3.5-Mc. crystal and all tank circuits tuned to this band. S_2 is open, since only one of the two 6V6s is used unless the stage is doubling frequency. Seven-megacycle excitation for the final may be obtained in any of three different ways. With a 3.5-Mc. crystal, L_1C_6 may be tuned to the fundamental, doubling taking place in the buffer stage with L_2C_{14} tuned to 7 Mc. and both 6V6s in use. Equivalent results should be obtained by tuning L_1C_6 to 7 Mc. with either a 3.5- or 7-Mc. crystal and amplifying straight through with a single tube in the buffer stage.

Fourteen-megacycle output may be obtained from a 3.5-Mc. crystal by doubling to 7 Mc. in the oscillator and doubling again in the buffer stage. With a 7-Mc. crystal, the doubling may take place in either oscillator or buffer as desired. Twenty-one-megacycle operation requires tripling frequency—from a 7-Mc. crystal—in the output circuit of the oscillator and amplifying straight through with a single tube in the buffer-amplifier, since the push-push arrangement cannot be used for tripling. Ten-meter drive for the final is obtained from a 7-Mc. crystal by doubling frequency in both oscillator and buffer.



Detail view showing the construction of the neutralizing condensers and the mounting of the 807s.

It is best to adjust the transmitter initially at the highest frequency at which operation is desired. With a plate supply delivering between 325 and 350 volts, the oscillator plate should draw about 15 ma., kicking upward a milliampere or two at resonance. This current remains about the same regardless of whether the oscillator is doubling or working at the crystal fundamental. Resonance in the oscillator output circuit is best determined by tuning the circuit for maximum grid current to the buffer stage. This grid current will run between 1 and 2 ma.

As soon as the buffer stage has been tuned up, the screen leads should be opened up and the individual screen currents checked for balance. C_7 should be adjusted carefully until the screen currents match when the plate tank circuit is tuned to resonance. The buffer plate current at resonance normally should run between 10 and 30 ma., depending upon the band of operation and whether one or two tubes are in use, when R_8 is adjusted to deliver required drive to the final stage. If the wiring to the buffer tubes is kept closely symmetrical and the tubes themselves do not differ appreciably, no neutralizing adjustment should be necessary when working the stage as a straight amplifier with one tube inactive, since the grid-plate capacitance of the inactive tube acts as the neutralizing condenser for the active tube. However, if self-oscillation should show up, the stage can be stabilized by introducing a small amount of capacitance, such as provided by spaced pieces of wire, between the

(Continued on page 108)