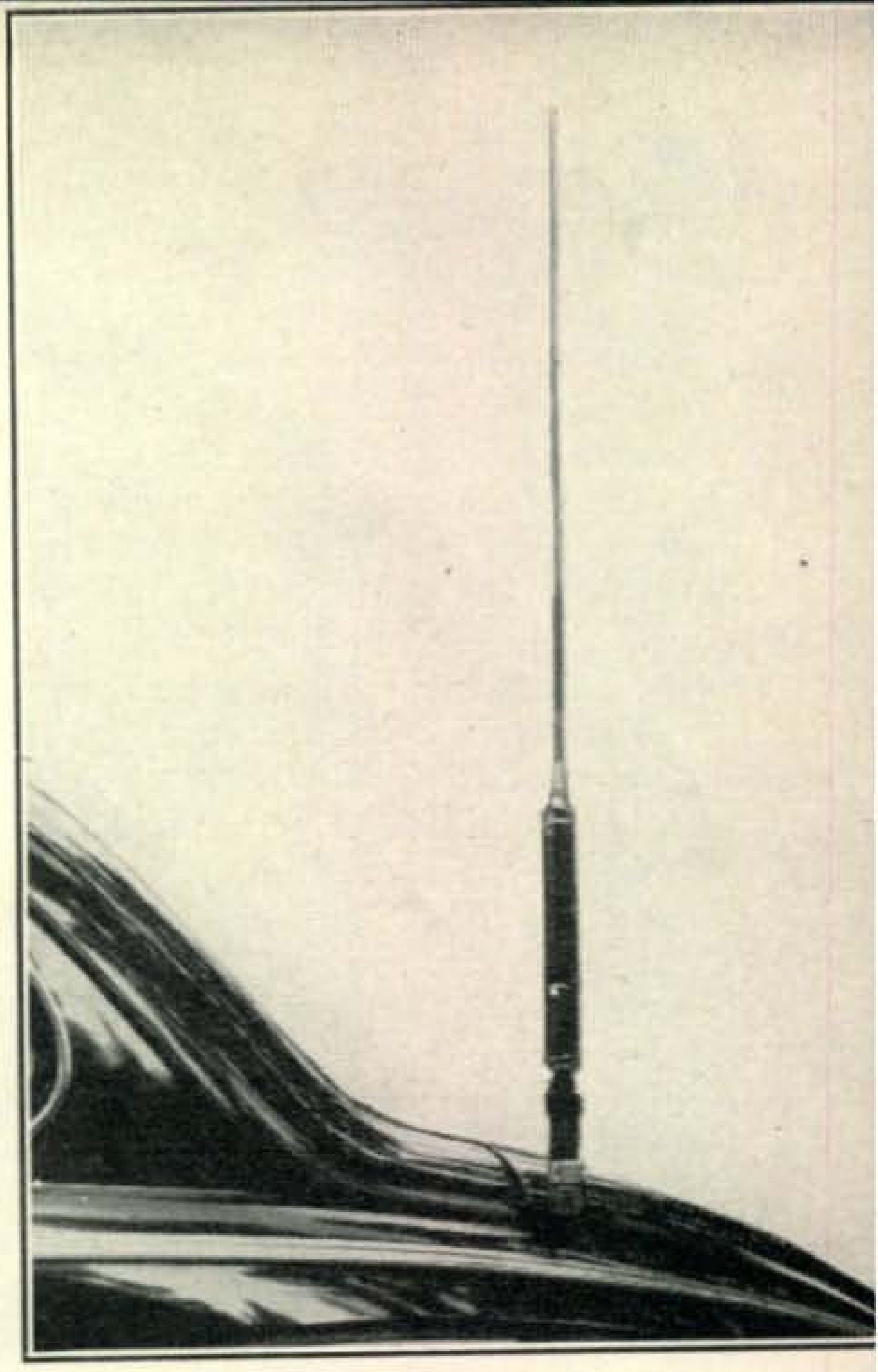
Fig. 1. The loading coil inserted at the bottom of the eight-foot whip. For ten meters, the same antenna is used without the coil. The over-all insulation is plastic tape, and contributed appreciable loss, but is essential to protect the coil in wet weather.



MOBILE ON 75

GEORGE M. BROWN, W2CVV*

Measuring signal readability in miles instead of db.

MOBILE OPERATION on the v-h-f amateur bands has been well investigated and its capabilities and limitations thoroughly charted over an extended period of years. The decision by the F.C.C. on July 14 that amateur mobile operations should be permitted on the lower frequency amateur bands, however, opened up a new field of endeavor. Little, if any, amateur operation has taken place on the lower frequencies using modern techniques and antennas of sizes suitable for mounting on passenger automobiles.

Believing that 75 mobile offered attractive possibilities, little time was lost at W2CVV in giving it a try. The results that have been obtained so far indicate that it has a number of advantages not possessed by the higher frequency bands. This is not surprising to those who have been operating on that consistent and reliable short and medium-haul band for many years, but the fact that an antenna capable of being mounted on a car could be made to radiate such low frequencies sufficiently well to make mobile operation practical has come as a surprise to many.

As an example of what can be done, on July 21, W2CVV left North Tarrytown, N. Y. at 7:30 a. m., having already called in to the usual 3990-kc round-table. All stations on the frequency were able to copy the signal from the mobile transmitter, and for the next nine hours and 250 miles, until signing off in Hyannis, Mass., contact was maintained with from one to six or more stations throughout New York and New England except for some 20 minutes in Providence, when overhead trackless trolley QRN was just a little too much competition. Signals fell off during the middle of the day, but they did not drop out. No definite skip zone was observed, although when leaving a station, signals dropped down to a rather low value by 15 or 20 miles, then started to build up again. The important thing is that they were continuously readable, although rather excellent conditions were necessary at both ends to avoid a few miles of 25 to 50 per cent readability. On the return trip the next day, similar results were obtained until dusk, then skip QRM began to override the car transmitter signals, although reception in the car was still good. This condition became rapidly worse, and by dark, although strong signals were received in the car from all distances up to 500 or 600 miles, the car transmitter was helpless in competition with a solid bandfull of potent QRM.

This represents the results obtained on two reasonably typical summer days, and the mobile antenna used was only a simple 7-foot whip, with all loading internal to the transmitter. Subsequent loading system investigations have indicated that substantial improvement in efficiency can be made.

The extent of interest in 75 mobile and the number of new mobile stations that are appearing on the band daily mean that development of improved equipment and techniques should be rapid. With the hope that some information on an operating station and a few suggestions on using available equipment will be of value in getting started, the following is offered.

Receiver

The two-band converter described in August 1948 *CQ* is used at W2CVV and leaves little to be desired. The conventional automobile broadcast receiver into which it works does not fall into the same classification. A double series gate noise limiter has been added to it, but is not a "must" as it is on 10. Such ignition noise as there is on 75, and it isn't bad even on jammed Westchester County parkways, does not tear the signals apart as it does

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on 10. Transmission line noise is bad along some lines, and trolleys are even worse, but these are not the types of noise that respond well to limiting, although it does help some. The best bet seems to be to stay away from such noise generators when weak signals must be received.

Where the bc receiver really falls down as an i-f amplifier is in selectivity. If 75 mobile turns out to be useful mostly by day, as presently indicated, this will be no severe limitation, and a little listening on the band after dark is not encouraging. No doubt the answer is a small, simple "Q5'r," but that is still on the docket for future developments.

The W2CVV converter is somewhat beyond the capabilities of most amateur workshops, but one expedient quite satisfactory for 75 only, involves cutting in two a 3 to 6 mc 274-N receiver, discarding the rear deck, the 12A6, the 12SR7 and the third i-f transformer. The second i-f transformer is then link coupled to the antenna input of the car bc receiver. The 1415 kc i.f. may be used as is, tuning the bc receiver to that frequency, or to be a bit more elegant it may be shifted to 1500. It will, of course, be necessary to replace the remaining tubes with their 6-volt equivalents, and rewire their heaters for parallel operation. Plate power can probably be obtained from the bc receiver power supply.

The original 274-N receiver could be converted for 6 volts and used as a complete receiver, but the selectivity of the 1415 kc i.f. is even worse than the usual bc receiver, and would be a severe handicap.

Transmitter

The 75 mobile transmitter installation is identical to the 10 meter one described in January 1948 *CQ*, with the exception that the BC-457, modified for 10, is replaced by a BC-696, also modified but to a lesser degree. Since the two transmitters are plug-in, and may be pretuned, band changing is quick and simple. The modification of the BC-696 is straightforward, but the main steps are listed for reference:

1. The original antenna relay is awkward to use for switching the antenna to the receiver, and it is suggested that it be replaced by the small one mounted beneath the chassis, which is easier to modify.[1] When making the modification be sure to replace the two fibre insulating cylinders around the contact assembly screws, and the one fibre contact insulator with similar ones made from polystyrene, since the output voltage may be high enough to break down the fibre. Rewire the oscillator plate directly to the power plug, instead of through the relay.
2. Rewire the heaters for parallel operation. One side of each PA tube heater will be grounded, and it is well to ground the cathodes directly also. This may be done by running a copper strap from one side of the chassis skirt to the other, picking up pins 6 and 7 of each socket on the way. This will provide a low impedance ground and tend to stabilize the PA.
3. File three of the holes in each 1625 socket to permit the insertion of 807s.[1] Use the same socket pins, 1 and 7 for the heaters, pin 4 for the grid, 2 for the screen and 6 for the cathode. Then jumper 2 and 3, and either 807s of 1625s may be interchanged with appropriate heater voltage. One pin 2 is originally used as a tie point, and the connections to it must be removed. For 6-volt operation, the 1626 oscillator tube should be replaced by a 6J5. Be sure pin 1 of the oscillator socket is grounded, to avoid a floating shell if a metal 6J5 is used.
4. At normal mobile power levels, one 807 will be capable of taking the full plate input, and there is no need of using two. With one, the 15,000-ohm grid resistor (mounted across the crystal socket) should be replaced by something like 25,000 ohms. The screen should be fed from the modulated plate voltage, through a dropping resistor. 20,000 ohms is about right for 450 plate volts.
5. A PA plate current jack should be installed, and another for reading PA grid current is useful for indicating oscillator condition. It is recommended that the plate current jack be insulated and connected in the high side, to read plate current only, without the screen.
6. The gang tuning arrangement is good, and with careful adjustment of the loading coil the PA will stay pretty well on resonance over the band with various loads. Nevertheless, after due and deliberate consideration of the mental hazard of wondering whether the PA really was right on the nose the PA padding capacitor was equipped with a short shaft extension and a dial and lock.
7. After all changes are complete, the oscillator should be recalibrated. It is merely necessary to adjust the trimmer capacitor across the circuit to bring one point back on, and unless there was something wrong with it before modification, the rest of the band will be on also. Do not change the position of the iron slug in the coil. If the top trimmer on the oscillator does not have enough range to compensate for the elimination of one PA tube, the plug in one end of the oscillator can should be removed, the little screw thus exposed loosened, and the oscillator padder lock moved to bring the "flat on" point somewhere near the center of the trimmer range.

[1] See January, 1948, *CQ*.

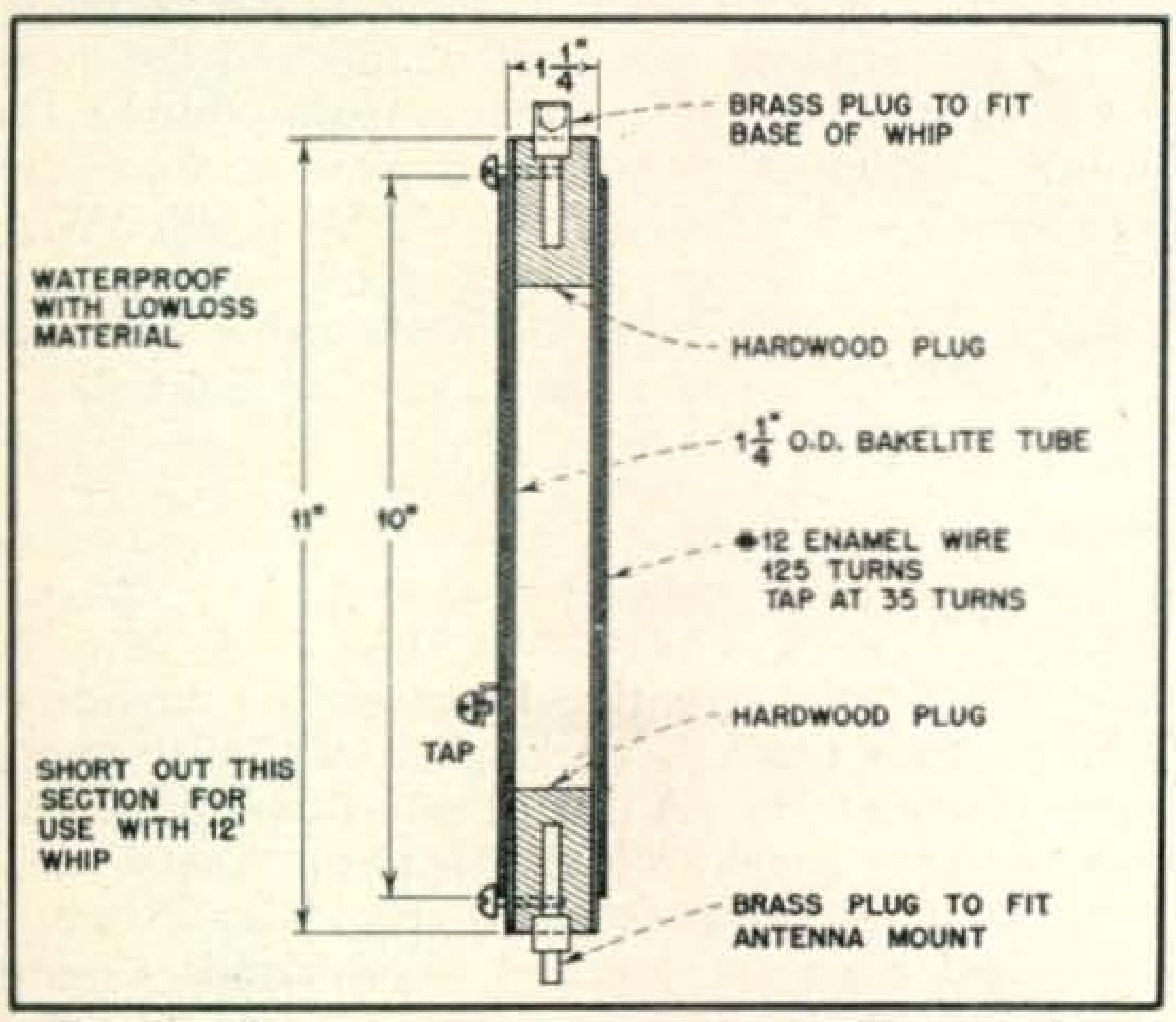

Fig. 2. Cross-section of the finished loading coil.

Antenna System

The antenna system is the weak link in the mobile station, and thus the one where the greatest improvements can be made. A whip antenna, usually 8 or 10 feet long at the best, must be artificially lengthened electrically or "loaded" to a full quarter-wave in order to take power from the power amplifier. Transmitters such as the 274-N series, designed for operation into random short antenna lengths, contain an internal continuously variable loading coil. The antenna may then be resonated by adjusting the loading coil for maximum PA plate current, or antenna current while maintaining the PA plate tuned to minimum. This can be done most effectively by reducing the antenna coupling to the minimum which will indicate loading, since this condition provides maximum sharpness and the PA tuning is little disturbed by the loading coil adjustment. After the antenna is resonated, the loading should be locked, the coupling adjusted for normal load, and the PA tuning rechecked.

When a whip antenna much shorter than a quarter wave is required to radiate power, both the current nto it and the voltage appearing on it are much higher than is the case with a longer antenna. Both of these conditions contribute to the high losses and low efficiency common to excessively short antennas. The high voltage increases the loss in any insulating material in transmission lines or used to support the antenna. The high current, of course, results in even more loss, in flowing through conductors having resistance, not the least of which are the many turns of the loading coil.

With as short an antenna electrical length as we are considering, the high voltage appearing on the antenna is essentially uniform throughout its length, and in fact is also present on the entire antenna system, including the transmission line, on the antenna side of the loading coil. Any capacity to ground beyond the loading coil thus has this high voltage across it, and carries a correspondingly high capacity current. This current, in addition to the actual radiation current, must flow through the loading coil, further contributing to the power loss. With the limited amount of power we have to start with in the usual mobile transmitter, we don't have to go very far with this process before we have little left to radiate from the antenna.

Here's just how serious this can be: With a seven-foot whip, and two and a half feet of RG8/U between it and the 274-N, using the built-in loading coil, results as mentioned previously were obtained. During some experimental antenna work, the transmitter was tuned up and loaded with *no* antenna connected to the end of the transmission line. There was no difficulty in obtaining full load, and the only departure from normal tuning was that two or three extra turns of loading coil had to be used. The *total* power output of the transmitter was dissipated in increased losses in the transmission line and loading coil.

The moral of all this, of course, is to keep the stray capacity to ground beyond the loading coil and the resistance of the entire antenna system as ow as possible. This does not strictly apply to top-loaded or center-loaded antennas, where the capacity serves a useful purpose in improving the current distribution which may more than compensate for the increased loading coil losses.

The usual methods of keeping the resistance down are applicable, but there are a few tricks we can play on the capacity. Since it is only the capacity beyond the loading coil that is doing us dirt, the most obvious thing to do is to take the loading coil out of the transmitter and put it beyond some of the capacity.

One expedient frequently used on small boats is to make the antenna from a cane or bamboo pole, wound with a spiral of wire. This is a form of continuous loading, and can be varied by using different turn-spacing along the pole. In some cases, this may be the best compromise for a 75 mobile antenna, but where trees are low, it would probably have a limited life. An experimental antenna was made by winding a solid layer of #18 dcc wire over the full length of a nine-foot whip, with taps included to permit shorting out various portions of the winding. It was found that shorting all but 12 inches at the bottom produced resonance with only a turn or two in the transmitter loading coil, and the improvement over a simple whip was nothing less than amazing.

75 METER MOBILE

With this as a start, two versions of a demountable base-loading coil were built, and found to perform equally well. *Figures 1* and *2* show the final version, which is capable of loading an eight-foot whip to resonance at 4 mc with the help of two or three turns of the built-in transmitter loading coil. It would, of course, have been possible to use no loading at all in the transmitter, by carefully adjusting the base-loading coil, but that would have meant making it variable to cover more than 10 or 15 kc, and would probably have added more loss than it would have taken out. A tap is provided on the coil, to permit shorting out the bottom 35 turns and resonating a 12-foot whip, for a little better performance where the longer one can be used.

Field strength measurements, using a receiver with an accurately calibrated S-meter, showed that the final loading coil gave a gain of 9 db over the same 8-foot whip without the coil. Measurements without the coil were made by shorting it out, to retain the same total antenna length. Similar measurements with a 12-foot whip gave gains of

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chokes provided the necessary inductance. Removing the grid by-pass stopped it immediately. Final measures were simple enough and account for the use of a fixed resistor in series with the grid choke before the by-pass. This resistor is not for the purpose of grid bias and should not be omitted.

In making harmonic checks don't forget to tune the parasitic chokes in the plate leads! The values given resonate somewhere around 80 mc and can give a decided increase in sixth harmonic output (14-mc operation) unless tuned. When so tuned, they represent parallel resonant trap circuits for this harmonic and are so used in this transmitter in addition to their regular function of detuning the plate circuit for u-h-f oscillation. Rather extensive search for harmonic output has clearly indicated the need for complete shielding of the final amplifier and all incoming power leads. It is very surprising to find different harmonics on individual power leads and regardless of the care taken to keep harmonics out of the antenna circuit all efforts will be undone unless the job is completed by shielding and filtering.

Here then is our new final amplifier. We like to think of it as our final-final, knowing of course that we will soon forget that we built this aluminum beauty by dint of much hard labor with file and hacksaw and start thinking about still another final. Even as we write these closing lines we are reminded of the commercial transmitter we once designed with motor-driven tuning capacitors and rotating coil turrets. Mmmmmm—all this—and TVI too! Maybe we had just better let this one be the final-final!

BEGINNERS SUPERHET

(from page 30)

Signals other than those on the amateur bands are excellent for test purposes and often will prove more satisfactory as they stay on for long periods, while the amateur signals will often cease just as that particular test or adjustment is reaching its peak.

Once reception is obtained, peak up the receiver by adjusting the i-f trimmers, *Ca* and *Cb*, until maximum i-f gain is obtained consistent with smooth regenerative action of the 6SH7.

A word of caution. Whenever working with the plate voltage on be very careful. Despite its low potential it can cause harm. In any case now is the time to cultivate the safety habit.

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6.6 and 12.6 db, without and with the loading coil. Thus the external loading coil produces an effective power gain of eight with an eight-foot whip and four with a 12-foot whip, over the same antennas with the loading coil built into the transmitter. When gains of this magnitude can be achieved by such simple means, even greater improvements in efficiency may well result from further development. Some of the commercial services have obtained marked improvement with a form of center-loading [2] which should be perfectly feasible for amateur operation.

[2] See QST, December.