

CASCODE TYPE FRONT ENDS

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Cascode tuners are not all alike. The author discusses three different types.

(Second of two parts)

IN THE preceding article we discussed the origin and advantages of the cascode amplifier. In this part we will consider two practical forms of the cascode circuit.

Pentodes versus triodes

The basic design problem of the r.f. stage is a compromise situation of devising an amplifier that contributes maximum gain with minimum noise. It has long been known that pentodes are more noisy than triodes, but triodes have not been much used because they have relatively low gain and require neutralization to prevent oscillation and regeneration. What is desired in an r.f. section is a combination to produce the high gain and good stability of a pentode with the low noise characteristics of the triode.

In addition to the noises listed in last month's article pentodes have "partition noise" as a result of random division of cathode current between the plate and screen. The relative noise of a tube is usually expressed as the value of an actual resistor which would contribute that much noise to a circuit. Lower resistance values indicate lower noise. A 6J4 triode (a special-purpose type) has an equivalent noise resistance of about 200 ohms, whereas a pentode like the 6AK5 has a value of approximately 1,880 ohms. It is possible to reduce the noise figure of a pentode by connecting it as a triode; with a 6AK5 this reduces the equivalent noise resistance to 400 ohms. The 6J6, 12AT7, 6BK7, 6BQ7, and 6BZ7 dual triodes, and the 6J4, 6C4, 6AB4, etc., in the single-triode types are all suitable for cascode application.

There is one serious disadvantage in a circuit employing triode amplifiers. In the grounded-cathode r.f. amplifier the plate-to-grid capacitance provides feedback which makes the amplifier unstable and encourages it to oscillate; this tendency increases with improvement in gain. Neutralization may prevent oscillation and reduce in-

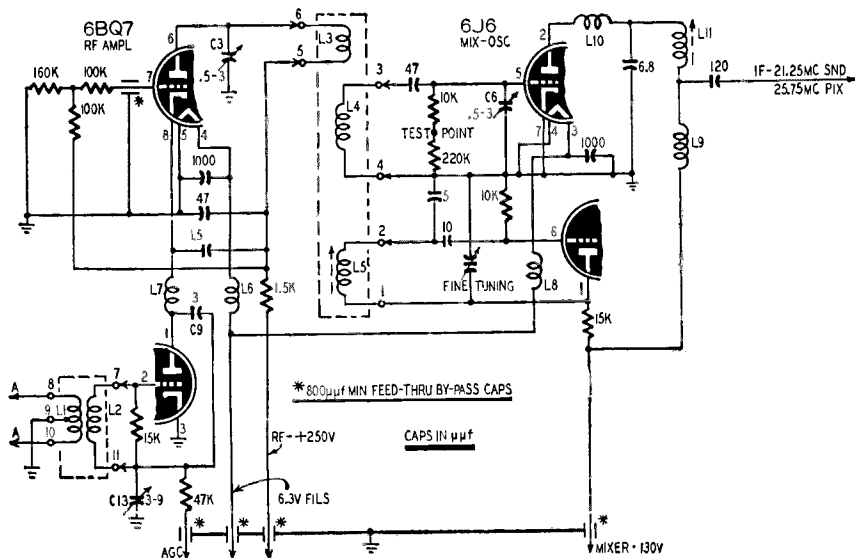


Fig. 1—Standard Coil model TV-2232 television tuner with cascode r.f. amplifier has direct coupling between input and output sections of the 6BQ7.

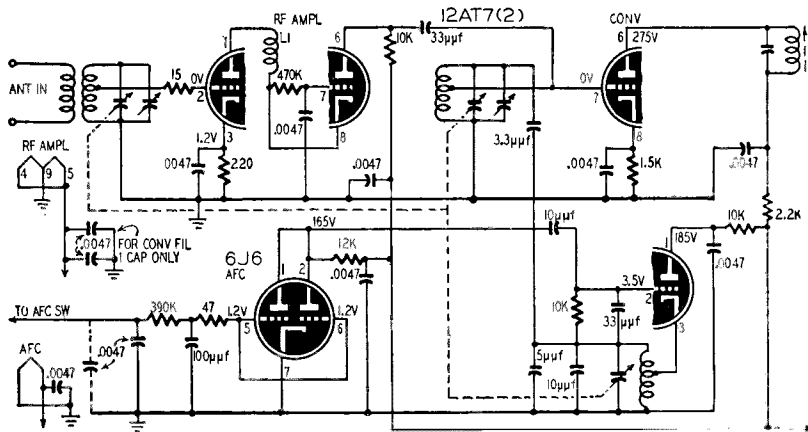


Fig. 2—Front end of the Browning RV-31 FM tuner has a 12AT7 twin-triode cascode r.f. amplifier, and a.f.c. on the local high-frequency oscillator.

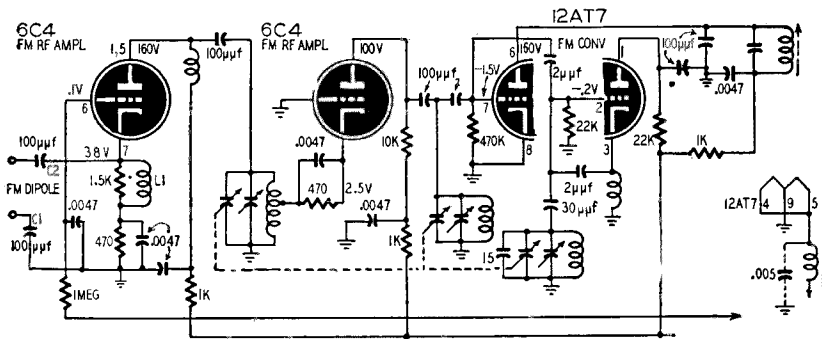


Fig. 3—Cascode-type r.f. amplifier using separate 6C4 triodes in the Altec-Lansing model 303A FM tuner. Both 6C4's are operated with grids grounded.

stability, but it is better to use a circuit that utilizes the triodes in relatively low-gain amplifier stages. This is an inherent virtue of the cascode r.f. amplifier.

On the other hand, a grounded-grid amplifier has excellent stability because the grid shields the input from the output circuit. But gain attainable with a grounded-grid amplifier is much less than the gain possible with a grounded-cathode amplifier. Any signal voltage which tends to make the cathode negative with respect to the grounded grid and increase the plate current is opposed, since the increased plate current flowing from ground to cathode tends to make the cathode *more positive than the grid*. This reduces both gain and sensitivity to weak signals.

Design considerations

Some careful attention to these design considerations will provide optimum amplifier performance:

1. The antenna input circuit should be balanced to ground since 300-ohm lead-in is standard for practically all TV and FM receiver inputs. This may be accomplished most readily by transformer-type coupling, but in some cases balanced impedance coupling may be used.
2. The antenna impedance should be transformed by the input circuit to a value close to the optimum source resistance for the triode used. This requirement may be most nearly met by winding the transformer for optimum noise rather than for perfect impedance match.
3. If possible, the input transformer should be so wound that a voltage ratio step-up is provided.
4. Capacitance tuning is undesirable for TV because it will vary the bandwidth of the circuit unless considerable loading is used. It may be used for FM because the frequency coverage there is relatively narrow (about 1.2/1).
5. If broadbanding is necessary it should be accomplished by some means other than by the use of loading resistors. Resistors in low-level circuits contribute thermal noise. This would defeat the basic design virtues of the cascode.

Source resistance

Optimum source resistance varies inversely with frequency. Thus for the TV band it will be necessary to design the turns ratio of the primary and secondary of the input transformer so that the apparent antenna resistance is the optimum source resistance at the grid of the input section of the cascode amplifier.

The optimum source resistance for a triode-connected 6AK5 is approximately equal to 70,000 ohms divided by the operating frequency. For 50 mc this would mean an optimum driving resistance of 1,400 ohms; for 100 mc this would mean an optimum driving resistance of 700 ohms; for 200 mc

this would mean an optimum driving resistance of about 350 ohms.

It is usually unnecessary to tune the interstage coupling circuit because the coupling between the grounded-cathode and the grounded-grid stages is loaded with the very low input resistance of the grounded-grid stage. Hence variable tuning is generally desirable only at the input to the grounded-cathode stage and in the output circuit of the grounded-grid stage (the input circuit of the mixer). In some cases it may not be desirable to tune the input to the grounded-cathode stage to eliminate feedback through the rotor shaft common to r.f., mixer, and oscillator stages, or to simplify tracking problems.

Fig. 1 shows a popular commercial application of the cascode circuit. This is the Standard Coil TV-2232 television tuner. The coils L1 and L2 are wound on one snap-in strip (as shown by the dashed outline), and L3, L4, and L5 are wound on another. Both strips are changed automatically when changing channels. L7 is a peaking coil which improves the over-all gain—particularly on the high-band v.h.f. channels. Grid-plate neutralization is provided in the grounded-cathode half of the 6BQ7 by C9, which feeds approximately the same voltage to the bottom end of L2 (terminal 11) as the plate-grid capacitance of the triode feeds to the top end (terminal 7). The identical feedback voltages at both ends of L2 cancel.

The variable capacitors C3, C6, and C13 are adjusted for full-channel bandwidth and maximum gain on channel 10. This gives substantially uniform results on all channels.

Cascodes for FM

Fig. 2 is the circuit of the cascode front end used in the Browning RV-31 FM tuner. Like the Standard Coil TV tuner, this has direct coupling between the grounded-cathode and grounded-grid sections. L1 resonates with the output capacitance of the grounded-cathode stage and the input capacitance of the grounded-grid stage to form a low-pass filter. The 6J6 a.f.c. tube, of course, has no relation to the cascode r.f. section, but keeps the oscillator tuned 10.7 mc above the signal.

Fig. 3 is a somewhat different form of cascode circuit used in the Altec-Lansing 303A FM tuner. Separate 6C4 triodes are used in the cascode stage, both operated as grounded-grid amplifiers. This eliminates the need for neutralization, and allows practically direct coupling (through C1 and C2) between the antenna and the input stage for a high signal-to-noise ratio. L1 resonates broadly in the FM band. Putting the first variable-tuned circuit between the two halves of the cascode amplifier raises the coupling impedance and increases the gain of the input section. Note that capacitance signal coupling is used between the two sections, so that both cathodes are only a few volts above ground for d.c.

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