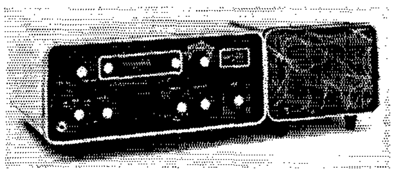
Recent Equipment

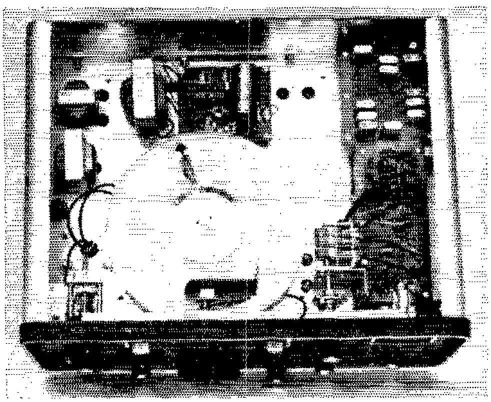
To acquaint you with the technical features of current amateur gear.



Hammarlund HQ-215 Receiver

The Hammarlund HQ-215 is an all-semiconductor receiver that is *not* miniaturized, and *not* lightweight. It's a full-size, full-poundage job, big enough for you to get your fists on the knobs, and heavy enough to stay put when you do. This is a fixed-station receiver, not the type to be packed in an odd corner of your kit bag when you go on a trip.

Like most receivers currently aimed at the amateur market, the HQ-215 has double conversion, with a bandspread tunable first-intermediate frequency and crystal-oscillator first frequency conversion. The tunable i.f., centered around 3055 kHz., covers a tuning range of 200 kHz.; thus at least two first-conversion crystals are needed for complete coverage of the narrowest of the amateur bands between 3.4 and 30 MHz., and more are required for the wider ones. As many as 24 crystals can be accommodated by the band switch, so up to twenty-four 200-kHz. tuning ranges can be made available without swapping crystals inside the cabinet. These ranges can be placed anywhere you like in the 3.4–30-MHz. spectrum. Standard equipment includes all the necessary crystals for the 80-, 40-, 20- and 15-meter bands, plus one (to cover 28.5–28.7 MHz.) for 10 meters.



The 7-inch diameter drum dial, occupying most of the central region of the above-chassis space in the HQ-215, has an effective scale length of 21 inches. With 200-kHz. coverage, this gives a spread of 1/8 inch or better per kHz. The v.f.o. is directly under the dial. The capacitor on the panel at the left is the c.w. pitch control. Audio stages are at the rear left. The three-gang capacitor alongside the dial drum is the preselector tuning control. The circuit boards containing the r.f., first mixer, and crystal-controlled h.f. oscillator stages run along the right-hand edge of the chassis.

The overall plan of the receiver, minus some details, is shown in Fig. 1, a block diagram. The single r.f. amplifier stage is followed by the first mixer, the output of which is between 2955 and 3155 kHz., depending on the signal frequency. The crystal-controlled h.f. oscillator drives both the mixer and a separate emitter-follower buffer, the output of which is available at a phono connector on the rear of the chassis. The first-i.f. output from the mixer goes through a 200-kHz. bandpass coupler to the second mixer, where it is combined with the variable-frequency oscillator output to convert the signal to 455 kHz. The v.f.o., which covers approximately 2.5 to 2.7 MHz., is coupled to the mixer through a buffer, and also to a second buffer whose output, like that of the h.f. oscillator, is brought out to a phono jack on the rear panel. A slot filter for notching out heterodyne interference is connected to the output side of the mixer; this is tunable over a range of plus-or-minus 6 kHz. centered on 455 kHz.

In the 455-kHz. i.f. system there is provision, following the second mixer, for selecting one of three mechanical filters. Only one, having a bandwidth of 2.1 kHz., is furnished, but additional ones having 6.0- and 0.5-kHz. bandwidths can be purchased separately. The filter is followed by three transformer-coupled i.f. amplifier stages, the last of which feeds the a.g.c. detector and either an a.m. detector or a balanced demodulator for s.s.b. and c.w. The beat-frequency oscillator for the balanced demodulator has separate crystal frequencies for upper- and lower-sideband reception, and there is also a tunable b.f.o. for c.w. The a.m. detector is followed by an audio preamplifier stage which is not used with the balanced demodulator.

Finally, there is an audio amplifier consisting of three stages, the second of which is a driver for the push-pull final stage. The last stage is transformer-coupled, with 3.2-ohm output for a speaker and 500-ohm output for a line or for operating an anti-vox circuit in a transmitter.

A brief run-down such as this gives little or no inkling of the actual circuit. As might be

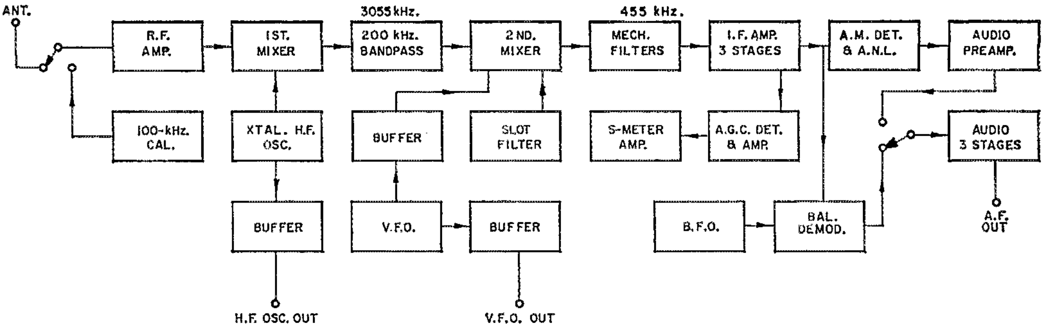


Fig. 1—Simplified block diagram of the HQ-215. Provision is made for three 455-kc. filters, but only one (2.1-kHz. bandwidth) is supplied as standard equipment.

expected at this stage of solid-state amateur receiver development, there are many features that will be of interest to those who build their own. We can't cover all of them in the space at our disposal, but have picked out a few that seemed to hold special interest.

R. F. Amplifier

In this day when field-effect transistors are all the rage it may seem odd that an "old-fashioned" bipolar transistor is used in the r.f. stage. Actually, from such listening checks and tests as we have been able to make, the receiver seems to compare favorably with tube front ends in respect to overloading and intermodulation. It could be that the triple-tuned arrangement shown in Fig. 2 is at least partially responsible. The added selectivity from individual tuned circuits, top coupled (L_{2A} and L_{3A}), no doubt helps protect the first mixer from strong signals a little off the wanted frequency. Another contributing factor may well be the selection of coupling taps.

The circuit itself is interesting in that one set of coils is used for the entire 3.4-30 MHz. spectrum, which is covered in four ranges switched to go with the h.f. crystal in use. The first range (the first three points on the 24-point switch) shunts relatively large values of fixed capacitance, 240 pf. shunted by a 200-pf. padder, across the 3-gang tuning-capacitor sections. The second uses just a 200-pf. padder, and the third adds nothing. The fourth shunts inductors (L_{1B}, L_{2B}, L_{3B}) across the regular coils to raise the frequency. This scheme, although not original with this receiver, is a simple one and saves a number of coils compared with separate inductances for each range.

The purpose of the low-pass filter shown in Fig. 2 is not mentioned in the instruction book. From the specifications given it appears to have a cutoff frequency somewhere between 30 MHz. and Channel 2. It is probably there to prevent spurious responses generated by strong television signals, which can be the curse of transistor receivers. If so, it works; we haven't heard any such responses on the set.

Slot Filter

The slot filter, Fig. 3, resembles the Selectoject in principle. That is, it is a Q multiplier followed by a phase inverter to give a sharp null instead of a peak. The circuit formed by L_1 and the capacitances in parallel with it is tuned to 455 kHz. with C_1 at its midposition, and varying C_1 tunes the circuit between about 449 and 461 kHz. Slot depth is set by the control of regeneration (Q multiplication) afforded by R_1. The col-

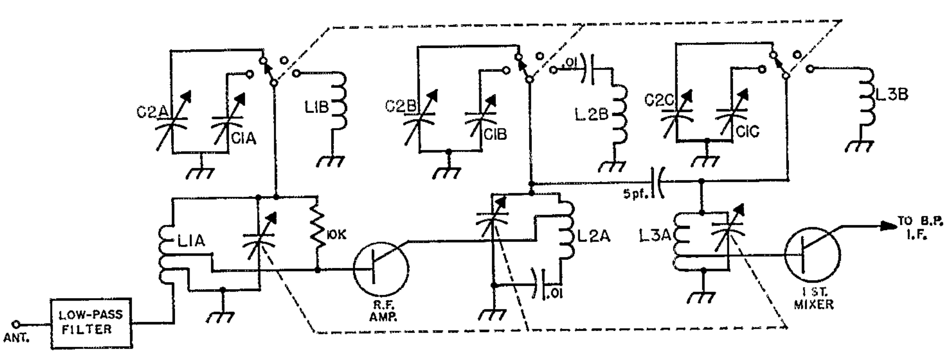


Fig. 2—Stripped-down signal-frequency tuning setup. Biasing and other details of similar nature have been omitted in order to emphasize the features essential to tuning. The four-point selector switch shown here is actually a 24-position switch divided into four sections in each of which the contacts are connected in parallel: points 1–3 connect to C_{1A}, C_{1B}, etc.; 4–6 to C_{2A}, etc.; 7–11, no connection; 12–24 to L_{1B}, etc.

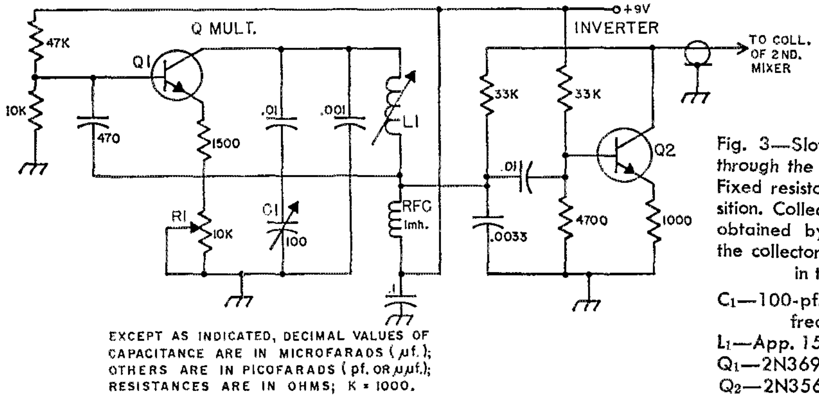


Fig. 3—Slot-filter circuit, tunable through the 455-kc. i.f. passband. Fixed resistors are ½-watt composition. Collector voltage for Q_2 is obtained by direct connection to the collector of the second mixer in the i.f. system.

C_1—100-pf. midget variable (slot frequency control).
L_1—App. 150 μh., adjustable.
Q_1—2N3693.
Q_2—2N3564.

lector of Q_2 is connected directly to the collector of the second mixer stage.

Slot depth is rated at 40 db., but we were able to get close to 50 db. by careful adjustment of the slot-depth control. For maximum suppression of a heterodyne the adjustment is critical. In actual use, the slot filter is quite effective, and does not take out too much of a chunk of the passband. Phone signals remain intelligible with the filter in use.

Gain Control and S Meter

The automatic gain control/S-meter system used in the receiver is shown in Fig. 4. The i.f. input to the a.g.c. rectifier, Q_1, is taken from a capacitive divider across the collector winding of the last i.f. transformer. Rectification takes place in the base of Q_1 after the signal overcomes the delay introduced by the voltage drop across the diode CR_1. This delay is adjustable by means of R_1. The collector output of Q_1 is a d.c. voltage proportional to the signal level, the i.f. component being filtered out by the 0.1-μf. capacitor from collector to ground. This d.c. voltage, amplified by Q_2 (note that this is a p-n-p transistor) is the a.g.c. voltage. Two a.g.c. "speeds" are provided, the slow one being the result of the relatively long time constant of C_1 and R_2. Fast a.g.c. release is obtained by switching R_3 in parallel with R_2, lowering the time constant. Attack time is very fast in either case, because C_1 can discharge rapidly through the collector-emitter resistance of Q_2 when the base is driven negative by the output of Q_1.

In the complete gain-control system, not shown here, the a.g.c. voltage from Q_2 is applied to the base of the first 455-kHz. i.f. stage. A.g.c. for the second 455-kHz. i.f. amplifier is taken from a tap on the emitter bias resistor for the first stage. From this same tap, the gain-controlling bias goes through a variable resistor (the manual gain control) to the r.f. stage and the first and second mixers.

The d.c. collector voltage of Q_2 also is applied to the base of Q_3, the S-meter amplifier. The emitter output — a d.c. voltage varying with signal strength — of this transistor is used to unbalance a bridge circuit having the S meter between its arms. R_5 is adjusted for balance at zero reading with no signal input, and R_4 controls the meter sensitivity. CR_2, since it will conduct only in one direction, prevents the pointer from "going negative" at any time.

Detectors

The a.m. detector is a simple diode rectifier. The audio preamplifier that follows it makes up for the higher gain of the s.s.b.-c.w. detector so that the input to the main audio amplifier is approximately the same with either method of detection.

The balanced detector for s.s.b.-c.w. uses a two-diode circuit that will be familiar to those who have been around long enough to remember "Single Sideband Junior".[1] The signal input from the secondary of the last i.f. transformer is balanced to ground, and the b.f.o. voltage is applied in parallel to the two diodes through a center-tap on a resistor shunting the input. The audio output is single-ended.

Two crystals, one above and one below the 455-kHz. passband, are used for shifting sidebands in the s.s.b. b.f.o. circuit. In addition, there is an adjustable-frequency b.f.o. for c.w. reception, cut in by a separate position on the mode switch; when this oscillator is in use its output goes through the crystal-controlled-b.f.o. transistor, now used as a buffer amplifier. On all three modes requiring the use of a b.f.o. the mode switch shifts the range of the variable-frequency oscillator (main tuning) so that the receiver calibration remains the same whether reception is on upper or lower sideband, or on c.w. This is why we said earlier that the tuning range of this v.f.o. is "approximately" 2.5 to 2.7 MHz. The actual range is altered a few kHz. by the switching for each mode in order to make retuning unnecessary.

Calibrator

The 100-kHz. crystal calibrator in the HQ-215 is not just a handy accessory but is an essential part of the setup procedure for each band, if the

[1] The circuit was originally a balanced modulator in a simple transmitter described in G.E. *Ham News* for November-December, 1950; also, *Ham News Sideband Handbook*.

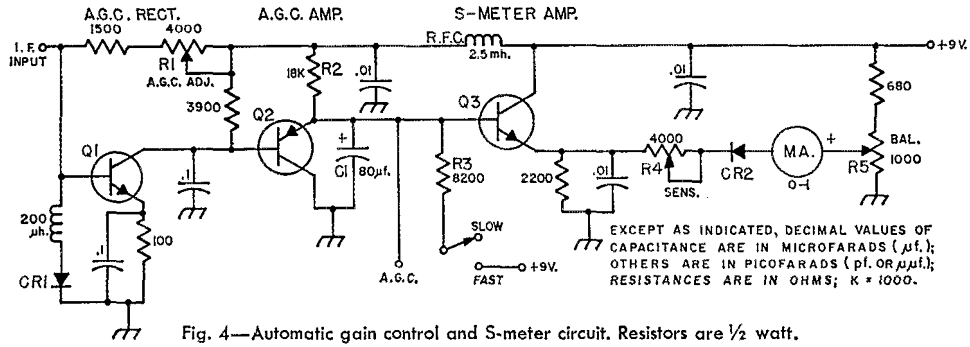


Fig. 4—Automatic gain control and S-meter circuit. Resistors are ½ watt.

C_1—80-μf. electrolytic.
CR_1, CR_2—1N541 (silicon).
Q_1—2N3693.
Q_2—2N3638 (p-n-p).
Q_3—2N3567.
R_1, R_4, R_5—Linear controls.

frequency readout of which the receiver is capable is to be realized. In changing tuning ranges, the first recommended step after setting the band switch is to put the function switch in the "calibrate" position, tune in the 100-kHz. harmonic at the low end of the range, and set the dial indicator to correspond. When the calibrator is turned on the antenna is disconnected from the r.f. input circuit so the 100-kHz. harmonic will stand out.

Setting the dial properly on each band is purely a mechanical adjustment. The fiduciary can be moved back and forth by a knob on the panel to make its position coincide with the calibrated points on the dial.

Power Supply

The receiver has an internal supply operating from the domestic power line. Either 120-volt or 240-volt supply, 50-60 Hz., can be used; the receiver comes wired for 120 volts and can be adapted to the higher voltage by a simple change in the power plug. The supply uses a step-down transformer and bridge rectifier to develop approximately 14 volts d.c. through a simple Zener-stabilized series regulator[2], the output of which goes through the circuit shown in Fig. 5. Alternatively, the input to Fig. 5 can be a 12-volt storage battery (negative ground is required) by using a different wiring arrangement in the power plug.

[2] The regulator system is similar to that shown on page 33, March 1967 *QST*.

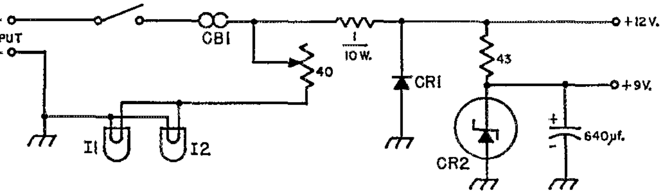


Fig. 5—Protective circuit in power supply prevents damage in case of breakdown causing short circuit in equipment, or in case battery polarity is wrong. CB_1 is a 2-ampere thermal circuit breaker, I_1 and I_2 are 12-volt pilot lamps, and CR_1 is a 3-amp., 50 p.r.v. silicon diode. CR_2, a Zener, regulates the 9-volt supply.

The circuit of Fig. 5 affords protection against an internal short-circuit in the receiver and against improper battery polarity when a battery supply is used. The entire d.c. load goes through a 2-amp. thermal circuit breaker, CB_1, which will open if the current exceeds the safe value. CR_1, across the d.c. line, is back-biased and does not conduct when the polarity is correct, but amounts to a short-circuit when the polarity is wrong. In the latter case, CB_1 opens and closes intermittently, causing the panel lamps, I_1 and I_2, to flash on and off and give a visual warning that something is wrong.

Although the 12-volt line is regulated, additional regulation for the 9-volt line is provided by the Zener regulator, CR_2. With the exception of the audio driver, audio output stages and the pilot lamps, which run off 12 volts, the entire receiver is operated from the 9-volt line.

Mechanical

Probably the outstanding constructional feature of the receiver is its drum dial. Calibrated in 1-kHz. steps, it is easily read to a fraction of a kilohertz, and just as easily tuned for "on-the-nose" reception. The driving knob has a flywheel for smooth action, and the reduction is such that one rotation of the knob averages 10 kHz. on the drum. The frequency calibration is very close to linear, so the tuning rate is practically the same everywhere along the scale.

The chassis, which is made of heavier-than-ordinary material, serves as the foundation for the entire cabinet. Front and rear panels are fastened to it, and joining the four corners of the panels are heavy grooved bars into which side, top and bottom panels can be slid from the rear. These are fastened in place by machine screws at the back, and one or more can be removed for access to the chassis without disturbing the others. It is a very convenient scheme for getting at any part of the interior. The only objection to it is that the sliding panels have a tendency to rattle if there is any vibration.

The circuit is divided into eight sections, five of which are on separate etched circuit boards. Each of these can be removed for servicing, if necessary.

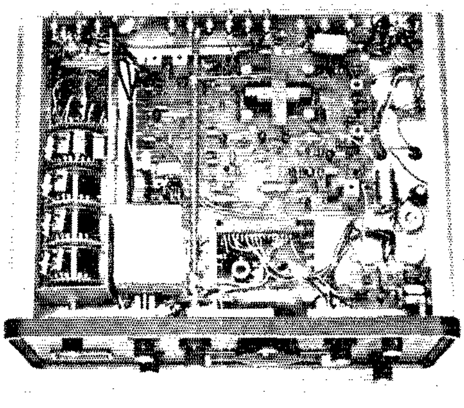
The rear panel is used as a heat sink for the power-supply regulator transistor and the two transistors in the audio output stage. There is a plastic baffle plate over them to prevent finger contact — for heat, not voltage.

The front cabinet feet are taller than the two in the rear so the receiver has a slight upward tilt, making it easier to read the dial and panel markings when the set is installed on the work surface of a desk or operating table.

The instruction book, besides the usual installation and operating instructions, has detailed service data (a little discouraging in spots, for the ham, since the recommended test equipment includes such exotic items as Tektronix scopes, Hewlett-Packard frequency counters, and Ferris signal generators!). A nice feature of the book is a set of "X-ray views" of the circuit boards, showing the etched pattern shaded and the parts placement in solid outline. Larger than life, these are easy to follow.

Miscellany

In the receiver we tested the v.f.o. calibration was practically on the button throughout the range, well within the rated accuracy of 500 Hz. between 100-kHz. calibration points. A couple of drift checks on the v.f.o. confirmed that after about an hour's warmup it easily met the specified less-than-100-Hz.-per-hour (total drift in one continuous run of over 12 hours, from a cold start, was almost exactly 1 kHz). The receiver is practically impervious to line-voltage variations, the v.f.o. frequency change being unmeasurable when the voltage is swung from 110 to 130.



The band switch and h.f. oscillator crystal sockets are along the left edge of the chassis in this bottom view. Next to it, on the panel, is the variable capacitor for tuning the rejection notch; the circuit board for the notch filter is immediately behind it. The large board occuping the rear center area contains the i.f. system and associated circuits; the long extension shaft operates the filter-selector switch through a panel control concentric with the function switch on the panel. The small board at the right front has the crystal-controlled b.f.o. circuits.

Hammarlund HQ-215 Receiver

Height: 7½ inches above supporting surface.
Width: 16 inches.
Depth: 14 inches.
Weight: 21 lb.
Power Requirements: 115/230 volts, 50/60 Hz., or 12-15 volts d.c.; 19 watts.
Price Class: $530.

The v.f.o. output for external use showed an amplitude drop of about 4 to 1 going from r.f. probe only to a 50-ohm load. The same change in loading caused the frequency to change approximately 500-Hz. at 2700 kHz.

We did not have the sharp (500-Hz.) filter for c.w. reception, and with the 2.1-kHz. s.s.b. filter the special tunable b.f.o. for c.w. proved to be of no great benefit. No doubt it would be advantageous with the sharp filter.

The a.g.c. *cannot* be switched off in the HQ-215, and the often-used technique of running the audio gain up and the r.f. gain down for optimum c.w. reception in interference (it's good on sideband, too, although few use it) doesn't work unless signals are quite strong. Normal-strength signals disappear in the noise when it is tried, so for a good signal-to-noise ratio the manual r.f. gain must be at maximum. This means that the a.g.c. must be full on, with the result that you may lose a weak signal when a strong one comes inside the passband and takes control of the gain. (Again, a sharp filter should help a great deal.) Also, as a minor annoyance accompanying fast-attack a.g.c., local noise "pops" such as light-switch transients depress the gain until the a.g.c. recovers. These things are inherent in a.g.c. as such, not peculiar to the HQ-215 — except that in the 215 the a.g.c. can't be defeated.

Like all multiple-conversion receivers, the 215 has some birdies. There is at least one on each of the eleven 200-kHz. amateur-band tuning ranges for which crystals are supplied. Their strength, in terms of equivalent antenna-signal input, ranges from 3 to 0.25 microvolts, most of them being in the lower part of this range. As they are harmonic responses of one type or another, they are easily recognizable by their rapid tuning rate.

Image rejection is rated to be better than 40 db. As the h.f. crystal oscillator is above the desired-signal frequency, the image will fall approximately 6 MHz. above the signal. Our checks showed image rejection of at least 60 db. on all amateur bands.

Using an average-responding a.c. voltmeter connected to the 500-ohm audio output, spot measurements at various frequencies showed that the 10-d.b. c.w./s.s.b. signal-plus-noise-to-noise ratio was well within the 0.5-microvolt specification. — *W1DF*