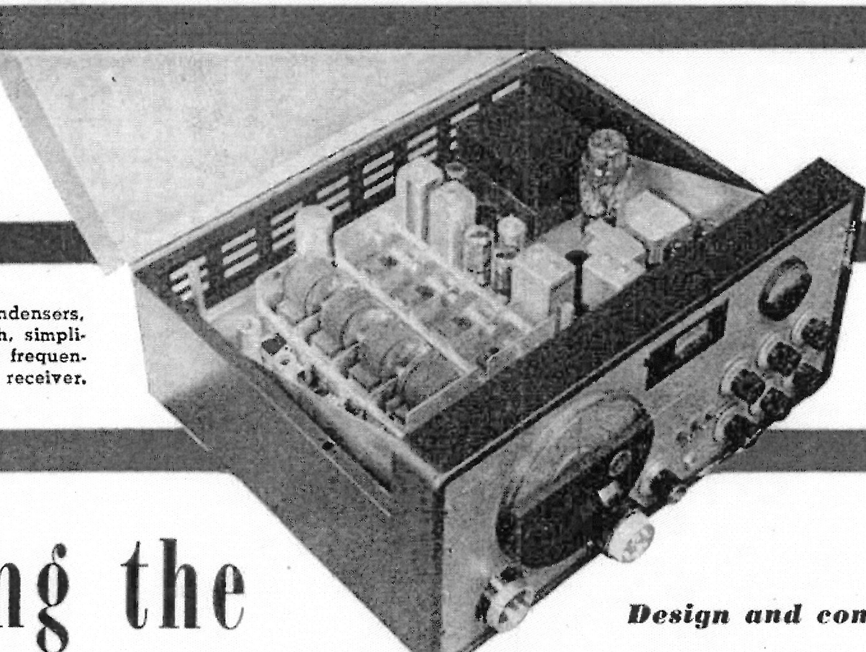


The use of split stator condensers, as shown in photograph, simplifies means of extending frequency range of postwar receiver.

Designing the POSTWAR RECEIVER

Design and construction of postwar equipment will present many new, interesting innovations.

By

BILL HALLIGAN, W9WZE and CY READ, W9AA

THE modern communications receiver has a long and varied ancestry. In its evolution it has acquired characteristics from every conceivable source—marine receivers, early regenerative variometer and varicoupler combinations, all-wave sets with plug-in coils, broadcast receivers, etc., etc.,—primarily however, it stems from decades of amateur experimentation and construction. In designing a new type of communications receiver, therefore, the first consideration must be the requirements of amateur operation—in sensitivity, selectivity, adaptability to varying conditions in the amateur bands, operating convenience, and frequency coverage.

Frequency Limits

In designing the new SX-42 the first radical departure from conventional practice was in the matter of frequency coverage. With the opening of many new v.h.f. and u.h.f. bands to amateur operation anything which makes it possible to cover more amateur frequencies on a single receiver is well worth-while. Then too, the vast majority of amateurs expect to find the broadcast band on any good communications receiver, as in these days of crowded living conditions it must frequently provide radio entertainment for the entire family. The assignment of 88 to 108 megacycles to FM and the obvious fact that frequency modulation is destined to become the dominant broadcast service, makes it highly desirable to provide for the FM band as well. Therefore, this new receiver must—and does—cover all frequencies from 540 kilocycles to 110 megacycles and is capable of c.w. and AM reception throughout that range and FM reception between 27 and 110 megacycles.

The Radio Frequency Section

The principal problem in covering such a tremendous span of frequencies is in securing good r.f. amplification. The gain per stage of a tuned radio frequency amplifier depends directly on the reactance of the coil, among other things, and if normal r.f. circuits are used it is necessary to employ tuning capacitors with exceptionally low minimum capacity in order to keep enough turns on the coils for any gain at all at the higher frequencies. This would not be too difficult except for the necessity of having capacitors large enough to tune the standard broadcast band as well. The solution was the development of a new "split-stator" circuit shown in Fig. 1.

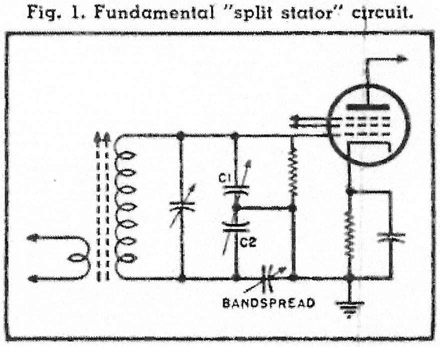


Fig. 1. Fundamental "split stator" circuit.

At the higher frequencies this split-stator circuit has many advantages over the conventional type of tuned circuit. The two halves of the capacitor being in series across the coil, the normal minimum capacity is cut in half. In addition nearly all circulating r.f. current is confined to the coil and capacitor, very little of it flowing through the rotor wiper contacts. In practical circuits employing band switching the coils for the two highest frequency ranges, 27 to 55 to 110 megacycles, are mounted directly on the band switch so that connecting leads are almost nonexistent. The switch itself is ruggedly built with positive contacts and is located directly underneath the main tuning gang. The extremely short connection between tuning capacitor and band switch are of silver plated copper strip to hold inductance outside of the coil itself to a minimum. Careful mechanical design has made possible r.f. circuits with band switching in which connecting leads are hardly any longer than would be the case without the band switch. Powdered iron cores are used throughout, even in the inductances for the highest frequencies, and the increased Q thus obtained assists greatly in maintaining high gain throughout the receiver's range. Two tuned r.f. amplifier stages employing miniature type 6AG5 tubes are used.

A single type 7F8 dual triode functions as high frequency oscillator and mixer. While not ordinarily used in receivers for the medium and high frequencies, triode mixers give a much better signal-to-noise ratio on the very-highs than the more conventional multi-element tubes. Temperature compensation is provided for the oscillator section, and plate power comes from a stabilized supply using a type VR-150 voltage regulator tube. This stabilized source is also used to supply the beat frequency oscillator and the direct current amplifier for the FM tuning meter to be described later.

Tuning Controls and Bandspread Arrangement

Wide frequency coverage calls for a high order of precision in the tuning mechanism and several new ideas have been incorporated in the control system. Main and bandspread tuning knobs are mounted coaxially and are placed at the lower right edge of the one-piece lucite main dial housing. A vernier dial in the form of a conic section is an integral part of the main tuning gear drive and rotates under a small window in the lucite housing, separately illuminated. A small locking knob is also mounted coaxially with the two tuning knobs and when rotated half a turn, alternately locks the main or bandspread controls to prevent accidental detuning. When the main tuning is locked its knob can still be turned through a slipping clutch arrangement but the condenser gang itself and the vernier and main dials cannot be moved. When the main tuning capacitor is turned as far as possible in either direction a positive mechanical stop locks the gear drive so that no misalignment can occur through accidentally forcing the knob too far.

Calibrated electrical bandspread in a receiver with such a wide tuning range presents a rather unusual problem because of the fact that some amateur bands occur where the main tuning capacity is nearly at maximum and others at the minimum capacity end of the dial. For example, the bandspread capacity needed to cover 300 kilocycles when the main tuning capacitor is near maximum is far greater than that needed for the same number of kilocycles if the main tuning is near minimum capacity. The problem was solved by designing a "trick" bandspread condenser gang. In this device the stator plates are especially shaped so that when the rotor is turned in to the stator in one direction the rate of change in capacity is comparatively slow whereas when the rotor is turned the opposite direction from minimum capacity a larger plate area is engaged, thus producing a greater change in capacity per degree of rotation. The bandspread condenser is cable driven from the outermost of the two coaxial knobs and the calibrated bandspread dial, located behind an oblong window in the center of the panel, is arranged to turn 180 degrees either way from zero depending on which amateur band is in use.

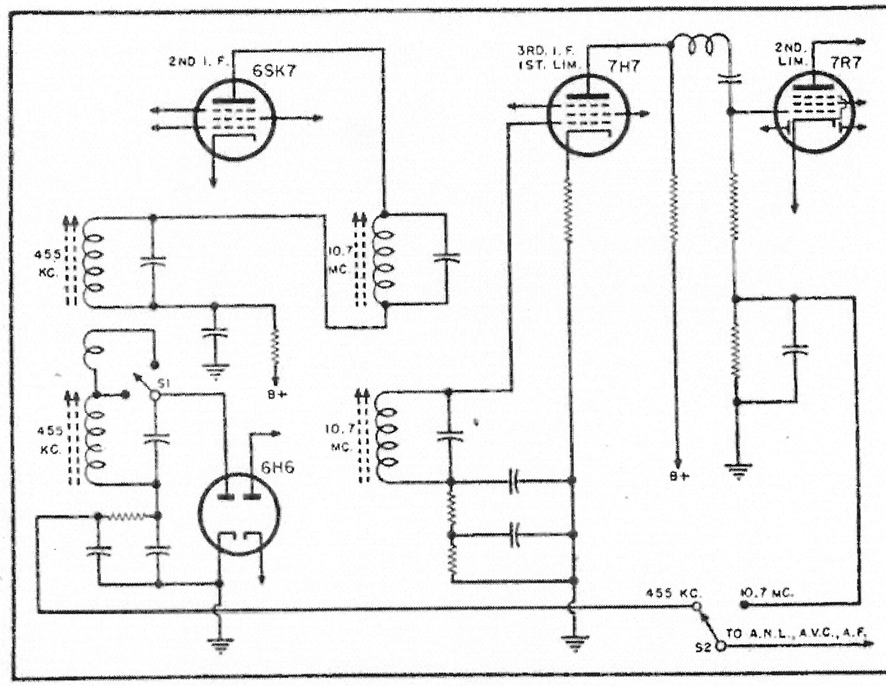


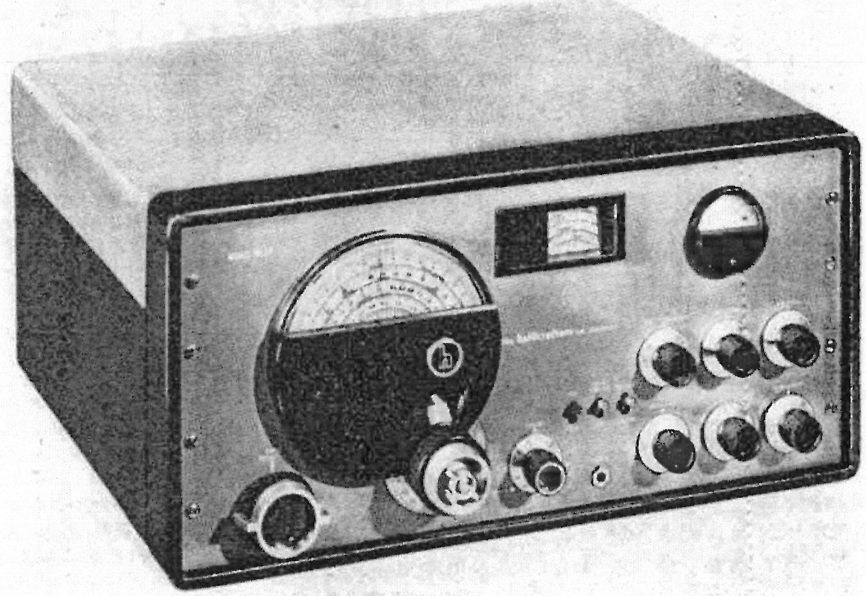
Fig. 2. Simplified diagram of second intermediate frequency amplifier.

This complete tuning assembly is adaptable to the preferences of almost any operator. The positive geared vernier provides absolute accuracy of reset or may be used as a bandspread dial by those who do not wish to use electrical bandspread. Approximately 2100 dial division on the vernier scale are required to turn the main dial from end to end. The combining of all tuning controls in one centralized unit is of great assistance in streamlining the appearance of the whole receiver and in removing the over-complicated look which has handicapped many fine models in the past.

Another radical departure from precedent in this receiver is in the i.f. system. Each i.f. transformer contains primary and secondary windings for both the 455 kilocycles and 10.7 megacycle i.f. channels and in most cases primaries and secondaries for both frequencies are connected in *series*. The change from 455 kc. to 10.7 mc. is automatically accomplished by two contacts on the band switch. In the first i.f. transformer only the secondaries are in series and one switch contact selects either of the two primaries while the other shorts out the 455 secondary and crystal filter components when the 10.7 i.f. is in use. Another switching arrangement is used to take the filter out of the circuit for regular reception.

(*Continued on page* 108)

The modern design trend is exemplified in this new receiver panel layout.



ting occurs with R_2 at about three-quarters of full setting where the detector is receiving approximately 65 "B" volts. —30—

Postwar Receiver

(Continued from page 51)

The changeover from 455 kc. to 10.7 mc. takes place between bands 4 and 5. As band 4 runs up to 30 megacycles and band 5 starts at 27 megacycles this arrangement permits the use of narrow-band standard communications receiver performance or wide-band v.h.f. performance on the amateur frequencies between 28 and 29.7 megacycles. The same flexibility is also available in the "QRM" band, 27,165 to 27,455 kilocycles, which is shared with industrial electronics, diathermy, etc.

The second i.f. transformer requires no switching except for a contact on the selectivity switch which connects the small auxiliary winding used in "expanding" the i.f. These extra windings are found in the 455 kc. section of the second and third i.f. transformers and the selectivity switch on the panel cuts in both, one, or none of these windings to give broad, medium, or sharp i.f. Three more positions on the same switch connect trimmer capacitors in the crystal filter circuit to provide broad, medium or sharp crystal, a total of six variations in selectivity available on frequencies between 540 kc. and 30 mc.

Fig. 2 is a simplified diagram of the second i.f. stage and parts of the third i.f. or first limiter and second limiter stages. Switch S_1 cuts in the auxiliary winding for expanding the i.f. referred to above. Switch S_2 is a part of the band switch. One diode section of a type 6H6 tube is used as an AM detector on the first four bands. On bands 5 and 6 when using AM or c.w. the first limiter becomes a third i.f. stage and grid rectification in the second limiter provides AM detection. As can be seen from the diagram, the two primaries in the third i.f. transformer are in series but the secondaries are not connected nor do they require switching as they feed into separate tubes.

B.F.O. and Additional Switching Circuits

A panel switch labeled *"Reception"* accomplishes most of the remaining switching operations. Its four positions serve: To connect the audio frequency amplifier to a phonograph input jack on the rear of the chassis; to connect the a.f. amplifier to the output of the FM discriminator which follows the second limiter stage; to connect the a.f. to S_2 (Fig. 2) for AM reception on any of the receiver's frequency bands; or to turn on the beat frequency oscillator for c.w. operation. In the FM position this switch performs another unique operation, it converts the type 7A4 b.f.o. tube to a direct current amplifier,

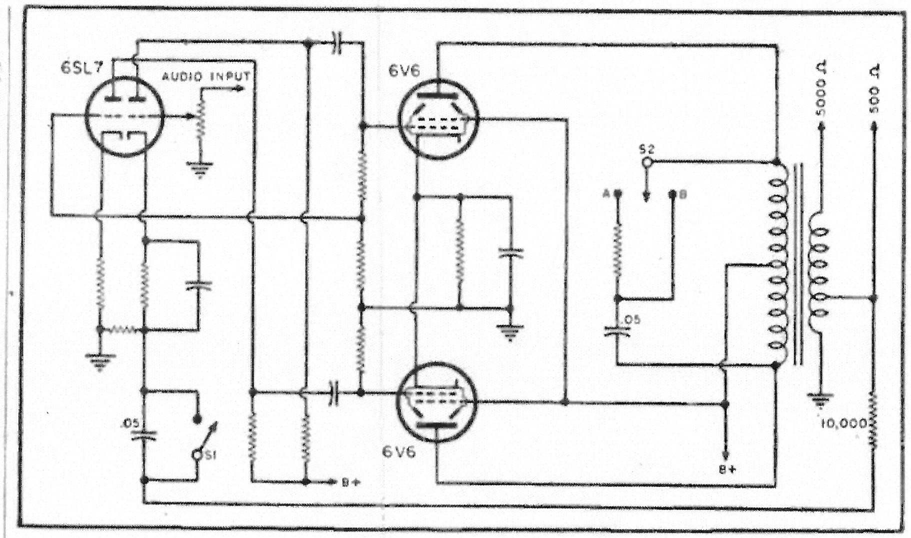


Fig. 3. Basic audio frequency circuit showing operation of tone control.

disconnects the S-meter from its normal position in the i.f. circuit, and connects both units to function as a sensitive FM tuning indicator.

The b.f.o. transformer contains two windings in series the same as the i.f. transformers. The b.f.o. circuit is a modified Colpitts with a small tickler added to assist oscillation on 10.7 mc. When operating on the lower bands using 455 kc. i.f., part of the band switch is open. On bands 5 and 6 this switch closes thus permitting oscillation at 10.7 mc. The lead to the b.f.o. trimmer on the panel is tapped down on the 10.7 mc. coil. This was necessary as a capacitor large enough to provide good b.f.o. adjustment on 455 kc. is so big that it would be almost impossible to tune if connected across the entire 10.7 mc. coil. As it is, the b.f.o. tuning is practically the same throughout the range of the receiver. Both b.f.o. windings are provided with adjustable iron cores.

Audio Frequency Amplifier

In order to take full advantage of the versatile performance of this receiver an exceptionally good audio system is incorporated. A type 6SL7 dual triode functions as an audio inverter and drives two 6V6s in push-pull as a final amplifier. A simplified diagram of the four-position tone control is shown in Fig. 3. For high fidelity operation switch S_1 is closed and S_2 is open. With this setting a small amount of the audio output is fed back to the cathode of the inverter tube thus producing inverse feedback at all frequencies. For bass boost S_1 is opened thus placing an .05 μfd. capacitor in series with the inverse feedback lead. This allows the higher frequencies to pass as before but effectively blocks the lower frequencies thus preventing degeneration of the bass. With the circuit constants shown here the bass response is increased approximately 12 db. with maximum gain in the vicinity of 100 cycles. For medium or low tone switch S_1 is opened and S_2 goes to position A or B thus attenuating the higher frequencies partially or almost altogether. In the high fidelity position the audio response curve of the amplifier is essentially flat from 60 to 15,000 cycles and an output of 5 watts with less than 5% harmonic distortion is easily attainable.

Actual performance in amateur operation has been very satisfactory as the combination of high signal-to-noise ratio, real stability, and high sensitivity leaves nothing to be desired. Over-all sensitivity of the receiver, measured with a 300 ohm dummy load across the antenna terminals, is less than 2 microvolts input for *500 milliwatts* output in any of the amateur bands below 30 mc. Performance at all other comunications frequencies is comparable.

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5" Oscilloscope

(*Continued from page* 42)

turned on. ALWAYS pull the line plug before making any changes or adjustments.

Operation

With the instrument completed and plugged into a light socket, test first for voltage breakdowns with only the rectifier tubes in place. If there is no indication of a short anywhere in the circuit, after about 5 minutes of operation, pull the line plug and insert the rest of the tubes. Set the controls as follows: R_{17} and R_{19} should be in their middle position or at about half scale at first; later they may be adjusted to center the image on the screen. Set S_2 at the upper position, and R_3 at about half scale, and it should be possible to get a linear sweep on the screen, which should make a straight line across the face of the tube when properly focused by manipulating R_{22} and R_{24}. The linear sweep should be formed for all positions of S_3 and R_{18} and at the higher frequencies, an audible whistle which seems to come from the internal structure of the 884 tube will probably be noticed. Varying R_4 should spread the line produced by the sweep oscillator from a point to a line extending beyond the limits of the screen. (Caution: Do not allow a point to focus for any length of time at one position on the screen of the cathode-ray tube as this may cause a dark spot on the screen.) If the sweep line is not reasonably straight, errors will be usually due to improper filtering of the power supply, stray hum pickup from some improperly shielded input connection, or stray magnetic fields from the transformers and chokes. To test for the effect of stray magnetic fields from the transformers, temporarily remove the CR tube socket from its mounting so that the tube may be turned up and away from the transformers as far as possible to check for improvement in the linearity of the sweep pattern. In most cases it will be necessary to encase the tube in a metal shield such as the one shown in the photographs, Figs. 3 and 4. This shield was made from a piece of 5" stovepipe cut to the correct length and formed and mounted as shown in the photographs.

If the linear sweep is functioning properly, a signal from an audio amplifier or oscillator may be coupled to the vertical input, either directly or through the 6SJ7 vertical amplifier, to produce a pattern suitable for viewing on the tube screen. A short length of wire coupled to the vertical input terminal and held in the hand should produce a sine wave through body-capacity pickup from the 60 cycle power line. This may be used as a simple test to check the functioning of the vertical amplifier. After being checked and placed in satisfactory operating condition, the instrument should be enclosed in a suitable case. The case shown in Fig. 1 was made of plywood and covered with imitation leather. Such a case is superior in many ways to a metal box. It looks and wears well, and there is less danger of shock or short-circuit. A ventilating hole in the top of the case, and one in the back, covered with screen wire, will insure adequate circulation of air to prevent overheating. Under no circumstances should the oscilloscope be enclosed in a box without holes for adequate ventilation.

Applications

It is not the purpose of this article to go into detail as to the uses of the completed oscilloscope. However, some applications to radio service work might be mentioned briefly. One of the most important and valuable uses is in the location of hum, noise pickup, and causes of intermittent operation. For this work, the portion of the radio circuit under test should be coupled to the vertical input through a short length of shielded wire. A small capacitor may also be used if necessary. Radio chassis and oscilloscope should have a common ground connection. S_1 will usually be set in the middle position, and R_1 adjusted to give adequate deflection for observation. Connection may be made to various points in the receiver and differences in hum, noise, and signal level noted directly on the CR tube screen. The gain in the vertical 6SJ7 amplifier is sufficiently high to permit tracing the audio signal through from the detector to the loudspeaker. This can be accomplished by moving a probe connected to the vertical input from one part of the circuit to another. The linear sweep will usually be set on one of the lower ranges while making these tests. The same general hookup is used for checking alignment and audio distortion. A square wave generator is a practical necessity for checking distortion in audio amplifiers. The squared wave is fed into the amplifier under test, and the output as observed on the oscilloscope will show deviations due to distortion. The square waveform makes it easy to detect minor variations.

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Practical Radio Course

(*Continued from page* 64)

respective conversion conductances of these types. Experimental data[2] shows that when such high-quality circuit components are used, the 6J8 and 6A8 converter tubes have practically the same translation gain and over-all stage gain at standard broadcast frequencies. At higher frequencies, up to 18-20 megacycles, these values for the 6J8 are substantially the same as at broadcast frequencies, whereas, at 18 megacycles the over-all stage gain using a 6A8 pentagrid converter may be less than one-third of that realized at 1500 kilocycles. These differences are due partially to the better conversion efficiency obtainable with 6J8 and to the low input loading of the tube.

It is evident from this discussion that through the use of a 6J8 triode-heptode converter tube (and similar types) the advantages of a separate oscillator and mixer combination are attainable in a single converter tube, with the added advantage of reduced space requirements and simplifications in wiring. Because of its low noise level and high conversion gain realized, the 6J8 has found wide application in compact midget receivers that have no preselector or r.f. stage.

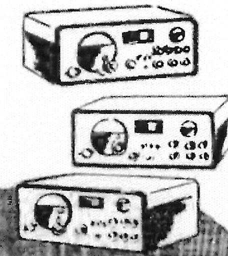
One disadvantage of the triode-heptode converter is that since the triode section shares a portion of the cathode area, the area that can be used for the oscillator is quite small, and as a result the oscillator transconductance cannot be made high.

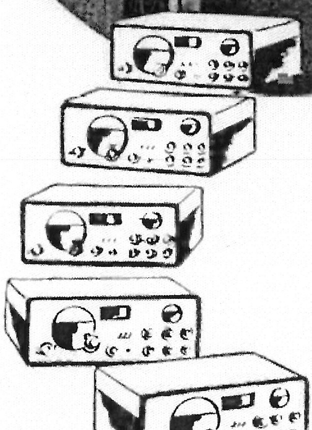
6K8 Triode-Hexode Converter Tube

The 6K8 *triode-hexode* converter represents another important advance in the development of stable electron-coupled converter tubes. Due to the

[2] "Converter Performance of Type 6J8 Triode-Heptode," *Sylvania Electric Products Corp.* "Engineering News Letter 43."

The first hundred sets are the hardest . . .





YOU can take it from Hallicrafters: the first hundred radio sets of any new model are the hardest. Hallicrafters is completing a run of 100 of the new Model SX-42. This extraordinary set has been more than a year in the making and behind it are more than 20 years intensive experience in the manufacture of high frequency communications equipment. The first 100 SX-42's have been checked, re-checked in a thousand and one testing operations. Because the set covers from 540 kc to 110 Mc continuously in six bands it must be as delicately balanced and precisely aligned as an expensive watch. One out of every five persons on the SX-42 assembly line is an inspector, watchdog over the strictest Hallicrafters standards. The first 100 SX-42's are now being placed in the hands of radio technicians, engineers, amateurs all over the world. These qualified critics will submit to Hallicrafters detailed reports. This final field testing of this great new receiver will bring the SX-42 one step closer to reality for you. Watch for the SX-42, wait for the SX-42 . . . the radio man's radio . . . the radio that's remembered by the veteran . . . preferred by the amateur . . .

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