THE RCA-7360

*By A. M. Farson, ZS6XT**

Since its introduction in 1960, the RCA-7360 beam-deflection tube has proved itself in balanced-modulator and balanced-mixer service in many SSB communications systems.

This tube offers practically all the advantages one could wish for in a balanced modulator. Both audio and carrier voltages can be fed to the 7360 single-ended, at high impedance; carrier suppression of the order of -60db can be achieved; linearity is superb, third-order distortion being 47db below SSB output voltage; the carrier-balance control is at RF ground and can be mounted remote from the tube.

Contrary to the case of a conventional double-triode modulator, the electron stream to the two anodes of the 7360 originates from a common source, thus ensuring excellent long-term stability of balance. In addition the 7360 does not load the speech amplifier or carrier generator.

What is not so well known about the RCA-7360 is its excellent performance as a small-signal mixer in receiving applications. Squires gives the following figures for a 7360 in a receiver front end:

Calculated: f= 30 Mc. Req = 1500 ohms. Thus Noise Figure = 5.3db. for a conversion gain of 20db.

Measured:	F Mc.	N.F. db
	29.5	5.5
	21.25	4.4
	14.25	4.3

From these figures, the author calculated that a receiver using a 7360 as the first mixer, with no preceding RF amplification, would have a sensitivity of 0.7 microV for 20db (S+N)/N at 14 Mc, the bandwidth being 3 Kc.

The second great advantage of the 7360 in receiver front-end service is its excellent cross-modulation resistance. Again, Squires demonstrated that a 100 mV 'unwanted' signal 14Kc removed from a 2 microV 'desired' signal, at a receiver bandwidth of 2.5 Kc, would cause just perceptible interference . . . i.e. when receiving a 2 microV SSB signal, an undesired signal only 14Kc away has to be 94db stronger to be just noticeable.

This superb cross-modulation performance is due to the fact that the 7360 behaves much as a Class A amplifier followed by an ideal switch. As the tube is balanced against the IF, 60 to 80db IF rejection can be obtained.

** 21 Wilds Crest, Killarney, Johannesburg (N.J.B.).*

(QSY de p. 10)

een of meer parameter behels, en indien verlang, kan werklike parameters, gemeet op 'n besondere transistor, voorsien word in die plek van die beperkings wat gewoonlik gekwoteer word.

Die aanvanklike doelwit van die eenheid moes reeds al hersien word ten einde in die toenemende aanvraag te voorsien, met die gevolg dat die 1964-proefhoeveelheid vermeerder moes word van die oorspronklike 10,000 tot 15,000 en verder is die produksiekwota vir 1966 verhoog van 50,000 to 175,000.

Met die beplanning van hierdie huidige projek was 'n eerste oorweging, behalwe die daarstelling van vervaardigingsprosesse wat verband hou met transistor-produksie, die aanstelling van 'n klein, dog doeltreffende span, wetenskaplikes en ingenieurs, wat in staat sal wees om 'n omvattende en fundamentele kennis op te bou van die tegnologie ten opsigte van die semi-geleierveld. Die verdere doelwit is om deur te dring tot die transistorvervaardigingsprosesse wat onder andere foto-litografiese- en diffusiebedrywe insluit. Hierdeur sal die eenheid in staat gestel word om sy eie silikon-skywe voort te bring, asook die vervaardiging van dun film en geïntegreerde stroombane op 'n latere datum. Deur die nouste samewerking te handhaaf met die Wetenskaplike en Nywerheidsnavorsingsraad in alle aspekte van semi-geleierontwikkelings, word daar verwag dat die eenheid in staat sal wees om 'n besliste bydrae tot toekomstige ontwikkelings op hierdie gebied te lewer.

STC (S.A.) vervaardig reeds 'n uitgebreide reeks naby-toleransie-, hoogtebetroubaarheids elektroniese komponente, onder andere: silwer-mika, poliestrine en papierkondensators, ossilator- en filter-type kwartz-kristalle en alle tipes klosse en transformators wat gebruik word by moderne kommunikasie-stelsels.

AN S.S.B. TRANSCEIVER

*by A. M. Farson, ZS6XT**

This article will describe a 14-Mc. SSB transceiver which was designed and constructed by the author in order to illustrate the superior performance of the RCA-7360, both as sideband generator and as receiver front end. The tube is followed immediately by a first grade 9Mc crystal filter, and the novel feature of this equipment is that the same tube and filter are used for SSB generation in the 'transmit' state, and as frequency converter and selective circuit in the 'receive' s[illegible].

A block diagram of the transceiver is given in Fig. 1. In the 'receive' condition, the incoming signal is fed via a tuned circuit to the control grid of the 7360, and the 5Mc. local oscillator voltage is placed in push-pull on the deflecting plates via a toroidal ferrite transformer. The local-oscillator signal on the deflection plates is balanced in order to minimize mixing at harmonics of the local oscillator (and consequent spurious responses) and local-oscillator radiation via the control grid.

The input tuned circuit matches the 7360 grid to a 50 ohm input. It is parallel-resonant at 14 Mc and series-tuned at 4 Mc, in order to attenuate the image frequency.

In practice, image rejection better than 60db has been achieved.

The 9 Mc IF is fed via the crystal filter to a conventional two-stage IF amplifier. The first tube is an EF183 high-mu pentode; the high gain (46db) of this stage more than overcomes the 3db insertion loss of the filter. The filter is correctly terminated by means of capacitive dividers. The second IF stage is an EF89; total IF gain is 86db.

The 9 Mc IF signal is fed to an ECC82 double-triode product demodulator, and the resulting audio drives the speaker via an ECC81 audio pre-amplifier and a transistor output stage. Maximum undistorted audio output is about 3 W into 3 ohm. The AGC voltage and S-meter drive are derived from the audio preamp. and the AGC voltage is applied to both IF stages.

An IF gain control is provided to reduce product-detector overloading due to very strong signals, and to give squelch action in local 'net' working.

In the 'transmit' state, the 9 Mc carrier is applied to the control grid of the 7360 and audio from a transistor speech amplifier to the deflection plates. The receiver IF and demodulator stages are cut off by means of a -50 V bias.

The 9 Mc SSB signal is fed to an ECC81 'unbalanced' balanced mixer where it is mixed with the 5 Mc local oscillator voltage. The resultant 14 Mc SSB signal is amplified by a tuned Class A driver using an EL83, which in turn drives the QQE 06/40 Class AB1 final. Two 15 Mc traps are fitted to suppress the third harmonic of the local oscillator. The final amplifier is followed by a pi-network and delivers about 65 W p.e.p. into [illegible] 50 ohm load.

The local oscillator signal is provided by a high-C Colpitts VFO using an EF91. The oscillator is temperature compensated; its frequency range is 5—5.5 Mc. The VFO is followed by an ECF82 bandpass amplifier and cathode-follower which drives the transmitter mixer and the 7360 deflection plates.

The carrier generator uses an ECC82, one section as oscillator, the other as cathode follower which feeds the 7360 grid and the detector. Two carrier crystals are furnished with the crystal filter; the filter center frequency is 9000.0 Kc. and the two carrier crystals are 8998.5 Kc for upper sideband and 9001.5 Kc for lower sideband operation. A 9000.0 Kc midband crystal has been provided for cw operation and to facilitate tuning up. Any one of these three crystals can be switched into the carrier oscillator.

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LIKE TO OWN AN SSB RIG AT A TOTAL COST OF R75?

The most expensive item in this transceiver is the McCoy Filter at about R36.

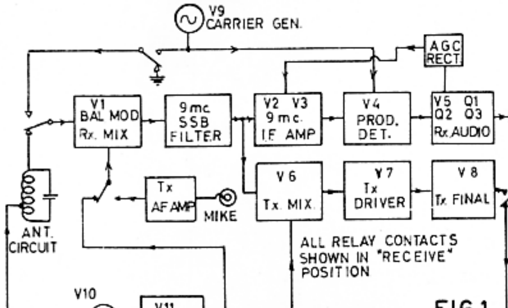


FIG.1

BLOCK DIAGRAM OF TRANSCEIVER.

The transceiver is equipped with a solid-state VOX and break-in CW system. A portion of the transmitter audio is fed to a two-stage VOX amplifier and a portion of the receiver audio to a similar anti-trip amplifier. The two audio voltages are compared in a diode bridge and the resulting dc voltage is fed to a two-stage dc amplifier which operates a relay. Optional push-to-talk operation is also provided. The DC amplifier has fast attack, slow-release action.

[illegible] keying circuit impresses a DC bias on the 7360 deflection plate, thus providing RF drive to the P.A., and also biases the DC amplifier on, thus operating the VOX relay and switching from 'receive' to 'transmit'. During keying, the relay remains operated while the transmitter is keyed by turning the DC unbalance on and off the 7360. The relay remains operated for about 0.5 sec. after the key is released. Thus break-in keying is possible as the system remains on 'transmit' between characters, but goes over to 'receive' at the end of a transmission.

Circuit Details

A complete circuit diagram of the transceiver is given in Fig. 2.

A functional description of the circuit is as follows: A relay switches the 7360 grid from the antenna tuned circuit (on 'receive') to the carrier generator (on 'transmit') and earths the deflection plates via 1000pF capacitors on 'transmit' thus removing the local oscillator voltage. This relay also earths one end of a coaxial line which feeds in the carrier signal (on 'receive'), the other end of this line being switched between the carrier-generator 9 Mc output and earth by a relay in the carrier-generator compartment. An OA79 diode across the carrier feed prevents the 7360 grid from being driven positive, with consequent distortion.

The local-oscillator signal is fed to the 7360 via a second coaxial line from the local-oscillator cathode follower: the sending end of this line is switched between the cathode of V11b (receive) and earth (transmit) by a relay which also switches the -50V cut-off bias from the transmitter tubes V6, V7 and V8 (on 'receive') to the receiver tubes V2, V3 and V4 (on 'transmit'). The 7360 is supplied with 150V regulated HT and 6V DC for heater. The 7360 anodes are coupled to the crystal filter via a modified 10.7 Mc FM discriminator transformer; it will be noted that the centre-tap of the bifilar primary is NOT bypassed for RF. The true RF centre-tap is the junction between the two fixed capacitors which resonate the primary. A differential trimmer

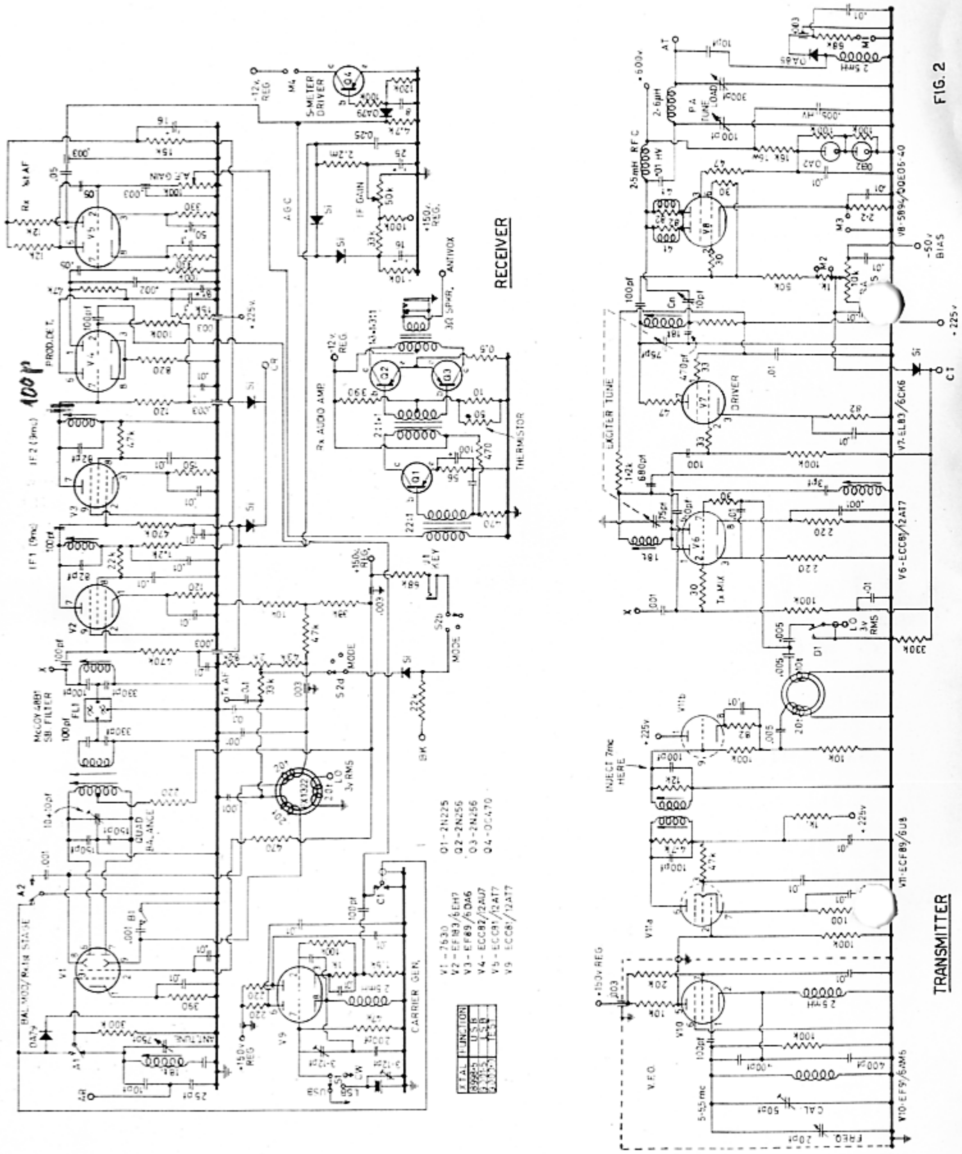
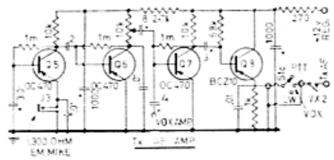
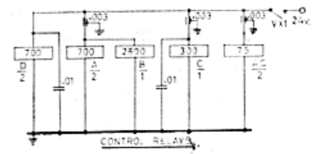


FIG. 2





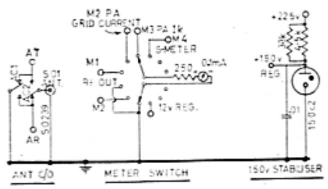
is fitted for quadrature balance adjustment.

The terminating impedance of the McCoy 48B1 SSB filter is 640 — 640 ohm in and out — i.e. 640 ohm across [illegible] pF. This impedance is matched to [illegible] 25 ohm output impedance of the 7360 by means of a capacitive divider across the secondary of the 7360 output transformer.

The filter is mounted astride the under-chassis shield in order to eliminate signal leak-through around the unit.

IF Strip

The IF strip is conventional, except that single-tuned circuits made from modified 10.7 Mc IF transformers have been used throughout. The output of the crystal filter is correctly matched to the dynamic resistance of the V2 (EF183) grid coil by a capacitive divider. Shields fitted across both IF-tube sockets are used as anchoring points for bypass capacitors on heater, cathode and screen pins. The sockets are so orientated that grid (No. 2) and plate (No. 7) pins are on a line joining the centres of the sockets. The [illegible]elds are at right angles to this line [illegible] are earthed to the chassis. With these precautions, the amplifier is stable without needing neutralization.



AGC and cut-off bias are applied to the grids of both IF tubes via the grid resistors.

Product Det.

The product detector (V4) is an ECC82 in a conventional double triode circuit. Carrier signal is fed to V4 continuously, the tube being biased to cut-off on 'transmit'. This biasing is necessary in order to break the feed-back loop which may be set up via the carrier generator, to the 7360, down the IF strip and back to V4.

The audio voltage from V4 is amplified in a two-stage R-C coupled amplifier (V5) using an ECC81. The output of the first stage V5A is fed via the AF gain pot, and a stepdown transformer to the 2N255 driver transistor (VT1) which drives the AF output stage (VT2-VT3) — two 2N256's in push-pull. The output transformer matches a 3 ohm speaker.

The audio voltage from V5B is rectified by a voltage-doubler to produce AGC voltage, and also drives the S-meter via a simple peak voltmeter and DC amplifier (VT4). The AGC rectifier incorporates a delay voltage divider and an IF gain control.

The transmit mixer V6 is the rather elegant circuit described in the RSGB Handbook, p. 315. It uses one-half of an ECC81 as a mixer and the other half as a heterodyne-frequency amplifier. The 9 Mc SSB signal is placed on the grid of V6A and the 5 Mc local oscillator signal is fed to the grid of V6B and the cathode of V6A in phase. The anodes are strapped, and the anode coil is tuned to the 14 Mc sum frequency. V6A acts as a grounded-grid stage as regards the local-oscillator signal and V6B behaves as a grounded-cathode stage. The local-oscillator voltages in the two anodes are approximately equal and are 180° out of phase, resulting in about 25db oscillator suppression.

The mixer tended to oscillate at 9 Mc, so it has been neutralized.

The driver stage (V7) is an EL83 Class A amplifier tuned to 14 Mc. The same shielding and bypassing precautions were taken on the driver as on the IF strip, as the EL83 is a high-mu tube. The stage has a voltage gain of about 30 and is stable.

Final

The final amplifier (V7) is a QQE 06/40 (5894) VHF double tetrode operating in Class AB1 with 600V on the anode and 250V regulated on the screen. The grid bias is -23V, which is obtained from a potentiometer across the -50V bias line. Both sections of V7 are strapped in parallel, each section having its own parasitic stoppers, and the amplifier is bridge neutralized.

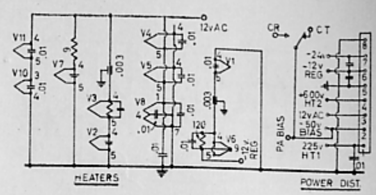
The QQE 06/40 was chosen in preference to the more usual pair of 6146's in the interests of better linearity. It is possible to bias this tube very close to projected cut-off at 600V plate voltage without exceeding plate dissipation — a state of affairs which is quite impossible with the 6146. It can be shown that the projected cut-off point on the transfer characteristic of a tube (the point on the -V axis where the projection of the linear portion of the transfer curve cuts the axis) is the correct quiescent operating point for optimum linearity).

Under these conditions, the QQE 06/40 delivers a maximum PEP output of 65 W for 100 W PEP input. No distortion measurements were made, but this tube is stated to give third order IP's about 35db below PEP output without RF feedback.

The final is coupled to the antenna via a conventional pi-network and an antenna relay.

The transmit mixer, driver and final are cut off by a -50V bias while on 'receive'.

The transmitter speech amplifier uses four transistors (Q5-8) and is driven by a 300 ohm magnetic micro-



phone. The amplifier is fitted with bypass capacitors to suppress feedback due to rectification of the RF voltage from the transmitter.

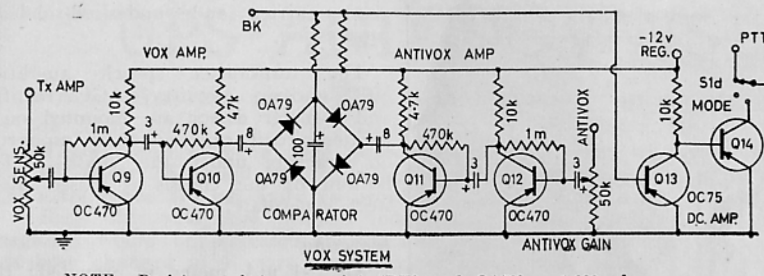
The VOX, anti-trip and keying circuits have been described above. The VOX relay operates all the other relays in the equipment, silences the receiver audio on 'transmit' by shorting the speaker and disconnects the transmitter audio from the 7360 on 'receive'.

The master oscillator is a high-C Colpitts circuit using an EF91 (V8). This oscillator is temperature compensated and drifts about 3 ppm/hour after 10 min. warm-up, which is quite adequate for amateur SSB service. The frequency range is 5-5.5 Mc. The VFO drives a 5-5.5 Mc bandpass buffer (V11A) using the pentode portion of an ECF82. The triode portion serves as a cathode follower to drive the 7360 deflection plates and the transmit mixer.

The purpose of the bandpass amplifier following on the VFO is to attenuate oscillator harmonics which might otherwise cause spurious responses and 'tweets' in the receiver. The cathode follower matches the bandpass transformer in the plate circuit of V11A to the low (about 200 ohm) input impedance of the transmit mixer.

The carrier generator (V9) is a conventional Pierce-Colpitts crystal oscillator feeding into a cathode follower. The tube is an ECC82. Three crystals are provided, viz.: 8998.5 Kc (USB), 9001.5 Kc (LSB) and 9000.0 Kc (midband). The appropriate crystal is selected by means of a switch.

Each crystal position is fitted with a trimmer for pulling the crystal onto the correct frequency. In practice the LSB and USB carrier frequencies are adjusted so as to place the carrier 20db down the side of the filter skirt.



NOTE: Resistance between point 'BK' and OA79's = 1,000 ohm.
Resistance between point 'BK' and Anti Vox Amp line = 100K-ohm.
Condensor between 'Vox Sense' and Q9 = 3 mfd, neg. to Q9.

The midband crystal is pulled precisely into the center of the filter passband, and is used for CW operation (in order to obtain full carrier) and for tuning the transmitter. The HT is 150 V regulated.

Power Requirements

The transceiver requires 12V AC for all heaters except those of V1 and V6: +225V DC for low-level stages; +600V DC for the final amplifier; -50 V DC for bias; -24V DC for relays and -12V DC for all transistor circuits and for the heaters of V1 and V6. All supplies are derived from a single power unit on a separate chassis. This power unit is conventional except for a transistor stabilizer which provides the -12V DC.

Construction

The transceiver is built on a 20 gauge, 15" x 9½" x 2¾" steel chassis. The panel is 14 gauge dural, 7½" x 15½".

The layout can be seen from Fig. 3. The VFO is in an 18 gauge steel case, 4" x 5" x 4" high; behind the VFO is the 7360 and its associated transformers. The IF strip runs along the back of the chassis; the final amplifier section is enclosed in a 6" x 6" x 3¾" aluminium cover with solid sides and a cane-metal cover and back. The transmit mixer and driver and their coils are between the final compartment and the VFO.

The crystal filter is just to the right of the 7360 output transformer.

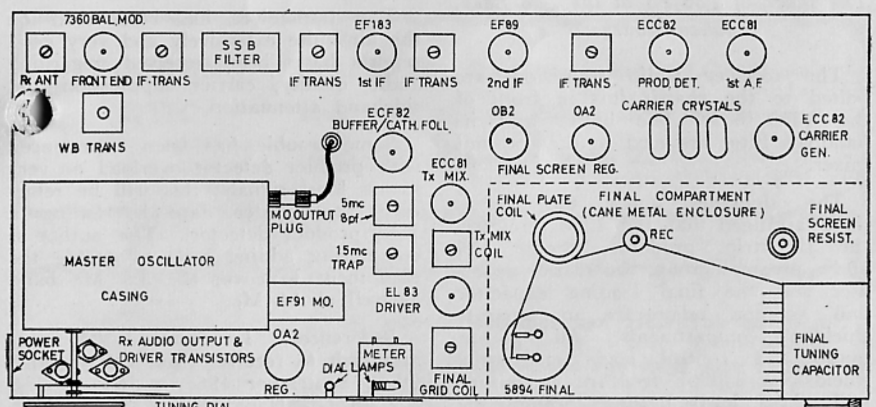
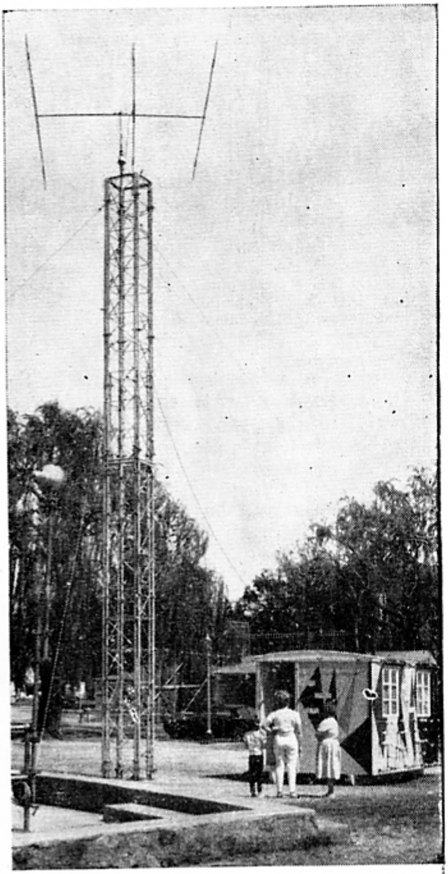


FIG 3



The shack of ZS6JFS at the Zoo Lake, Johannesburg.

The receiver audio transistors are bolted to the chassis just in front of the VFO box. The buffer and its bandpass filter are next to the transmit mixer.

The shielding under the chassis is so arranged that the 7360 circuitry, the IF strip, product detector and audio preamp. group, the carrier generator and the final loading capacitor and antenna relay are in separate shielded compartments. All power, audio and control leads enter the shields via 3300pF feedthru capacitors, and all rf leads passing through the shields are run in coax. This rather elaborate shielding is absolutely essential in order to ensure stability and good carrier and undesired-sideband suppression.

The transmitter speech amplifier, VOX-antitrip circuitry, AGC rectifier and S-meter driver are mounted on a printed-circuit card which is supported on brackets under the chassis. The bottom of the chassis is closed by a steel coverplate.

Metering

An 0-1 mA meter is provided; this can be switched to read Final cathode current, transmitter RF output voltage, final grid current (as an indication of overdrive) and signal strength. The meter scale is calibrated as follows: 0-140mA, O-30V and an arbitrary S meter scale.

Performance

The following performance figures were obtained by measurement:

Receiver: Sensitivity 0.6 microV for 20db (S+N)/N. at 14.2 Mc. Adjacent channel selectivity -6db at 1.35 Kc, -55db at 1.95 Kc from centre of filter passband. Image rejection: Better than -60db. IF rejection: -80db. Spurious responses: -80db. Cross modulation: A 100mV signal at the input causes just perceptible interference with a 2 microvolt signal about 25 Kc away.

Transmitter: Power input 100W pep. Power output 65W pep into 50 ohm. Carrier suppression -60db. Unwanted-sideband suppression -55db. Spurious signals -50db or better.

The transceiver has been used on the air quite extensively and very good reports have been received regarding audio quality, carrier suppression and sideband attenuation.

Some trouble has been experienced with product detector overload on very strong local signals; this will be remedied at a later date by fitting a 7360 product detector. The author is considering adding coils to enable the equipment to cover the 3.5 Mc band as well as 14 Mc.

References: 1. Squires, "A new approach to receiver front end design", QST, September 1963, p. 31.
2. RSGB Handbook, p. 315.
3. Collins Radio Co., "Fundamentals of SSB", chap. 7.