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The "Twomobile" A 144-Mc Transceiver

By

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THE TWOMOBILE is a complete, compact, two-meter transceiver designed primarily for mobile application. Its carefully chosen tube lineup provides for efficient performance from a 250 to 300-volt, 100-ma vibrator-type power supply — power-supply drain, consistent with reasonable power output, was of prime consideration in the design of this unit.

The design of the Twomobile is quite straightforward and does not incorporate any complex or tricky circuits. The receiver section is a superheterodyne, using a superregenerative second detector. The transmitter section employs a 6AK6 trit oscillator (with an 18-Mc crystal and 36-Mc output), a 6AK6 doubler, and a 5763 doubler-final.

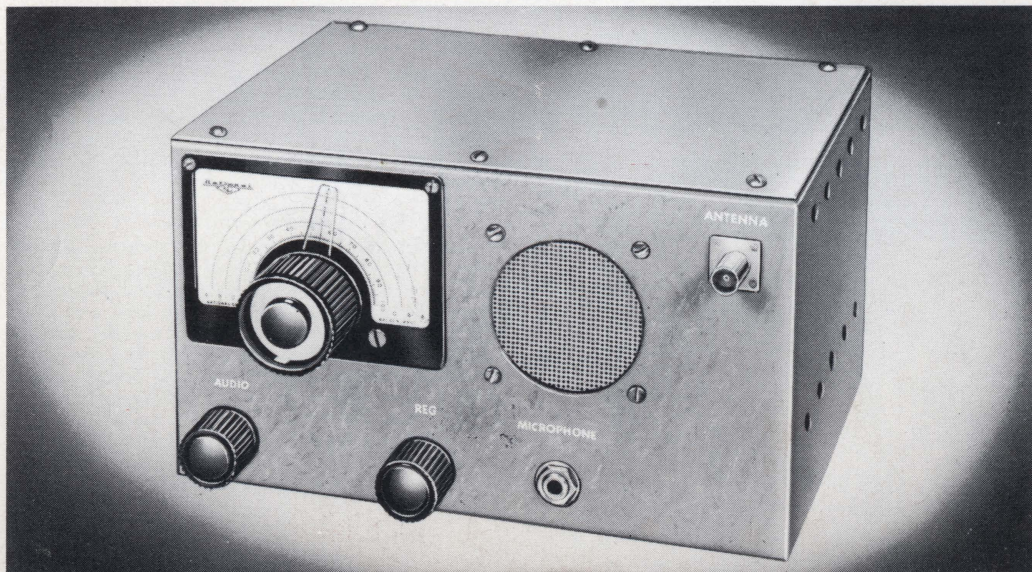
During transmission, the receiver audio amplifier functions as the modulator. All switching from "transmit" to "receive" is accomplished by

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Both portable and mobile operation are becoming increasingly popular, and the current Civil Defense mobilization program has done much to stimulate and intensify this trend. The transceiver described in this article, nicknamed the "Twomobile" for obvious reasons, has displayed excellent performance in mobile operation and is readily adaptable to fixed-station or portable installations. In mobile operation, the Twomobile has made 100 per cent solid contacts with fixed stations located 35 miles away—the power output is approximately 1½ watts.

means of a three-pole control relay. Operation of this relay is controlled by means of a push-to-talk microphone switch. This relay, RL, switches the B+ voltage and the antenna from the receiver section to the transmitter section while simultane-

Fig.1. The Twomobile—a straightforward, efficient transceiver for mobile operation.



ously opening the speaker voice-coil circuit and completing the ground connection to the cathode resistor of the final.

Receiver

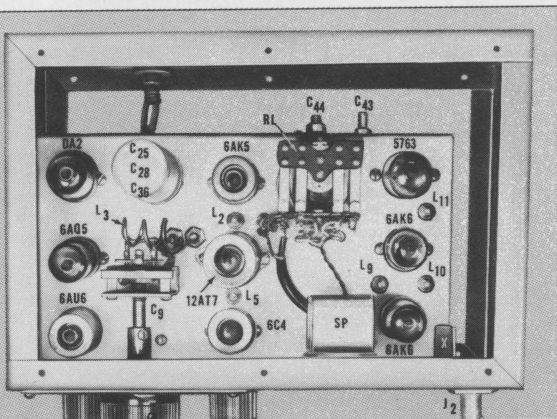
As shown in the receiver portion of the schematic diagram, it is apparent that the front end is of conventional design comprising a 6AK5 rf stage and a 12AT7 mixer-oscillator. The rf and mixer stages are both fixed tuned, thereby eliminating the usual bothersome tracking problem. At the frequencies that these stages operate, the operating Q of each coil is inherently low and little is to be gained by adding any extra tuning. Instead, these circuits are peaked to the approximate band center. A Hartley oscillator has been found to provide the best results in this frequency range. With the specified values of grid resistance and capacitance, the oscillator did not exhibit any tendency to superregenerate — a condition which so often plagues high-frequency oscillators. A one-inch length of 75-ohm twin lead, connected between the mixer and oscillator grids, serves as a coupling capacitor, providing optimum oscillator injection voltage.

The mixer plate is shunt fed through a 100- μ h rf choke and is capacitance coupled to a 6C4 superregenerative detector. The choke is used instead of a resonant circuit, with some sacrifice in selectivity, due to the inherent difficulties, including "suck-outs," of coupling to this type of circuit.

The use of this detector has several advantages over a conventional intermediate-frequency system, especially for mobile work. It combines high sensitivity with desirable space- and component-saving features. At least three if stages would be required to provide the same gain. The selectivity is considerably less; however, in the interest of compactness, the loss of selectivity is a justifiable sacrifice. In this application the superregen's inherent avc and noise-limiting action is highly desirable. A squelch filter, consisting of C₁₈, C₁₉, and L₇, completes the detector circuit.

In a receiver of this type, the selection of the intermediate frequency is quite flexible, there being only one tuning adjustment, L₅, to consider. During the breadboard phase of the Twomobile design, frequencies between 10 and 75 Mc were tried satisfactorily. Although an intermediate frequency of 30 to 35 Mc appears to be optimum for satisfactory operation of the superregenerative detector, the use of a frequency in this range can present an interference problem (TVI in reverse) if the image frequency falls within a TV channel.

Fig. 2. Top view of the Twomobile. Note that this layout of components permits maximum utilization of the chassis area, and provides plenty of space between components for adequate cooling.



MEET THE AUTHOR



H. W. Brown, Jr., W2OQN

Wally has been a ham for more than fifteen years, operating first as W1KIQ from West Medford, Massachusetts. Upon graduating from Tufts College in 1942 with a BS in electrical engineering, he joined RCA Victor. In 1948, after spending six years as a design engineer in the Crystal Engineering Section, he transferred to the Aviation Engineering Department where he is now working on military communications equipment.

In the past few years he has written articles for *CQ* and *HAM TIPS*. A past president of the South Jersey Radio Association, Wally is currently on the board of directors, a member of its mobile emergency corps, and an enthusiastic participant in all its activities. His ham activities are primarily experimental, but schedules with his uncle, W1CWZ (who gave Wally his start in ham radio), keep his hand in on 40 and 80 cw.

His *XYL* is Madeleine, and they have two harmonics, Ronnie 10, and Peter 5. The Browns reside in Haddonfield, N. J.

In a high-signal area, such interference can be very annoying. To sidestep this problem, it was necessary to choose an intermediate frequency of 11 Mc even though the detector design became slightly more critical.

In actual practice, these images are usually low in signal level and, in many locations, cannot be heard. Outside the TV service areas, any convenient intermediate frequency may be employed. The image frequency may be calculated by subtracting twice the intermediate frequency from 144 (to 148) Mc. For those who prefer to experiment with various intermediate frequencies, one other more obvious precaution should be heeded: Select an intermediate frequency having harmonics which fall outside the two-meter band; i.e., do not employ the following frequencies: 24 Mc, 36 Mc, 48 Mc, etc. If a higher intermediate frequency is selected, detector coil L₅ should have a smaller number of turns, and the values of R₁₀ and C₁₆ should be changed to obtain the optimum quench frequency.

Audio Circuits

The first audio stage in the receiver section employs a resistance-coupled 6AU6. Since this audio system is also employed as a modulator, rf filters (R₁₅-C₂₁ and L₈-C₂₃ in the grid and cathode circuits, respectively, of the 6AU6) are incorporated to prevent rf pickup and resultant feedback during transmission. A 6AQ5 audio-output stage and a two-inch, permanent-magnet speaker provide a good working audio level.

During transmission, the receiver rf stages are disabled by means of relay RL which transfers

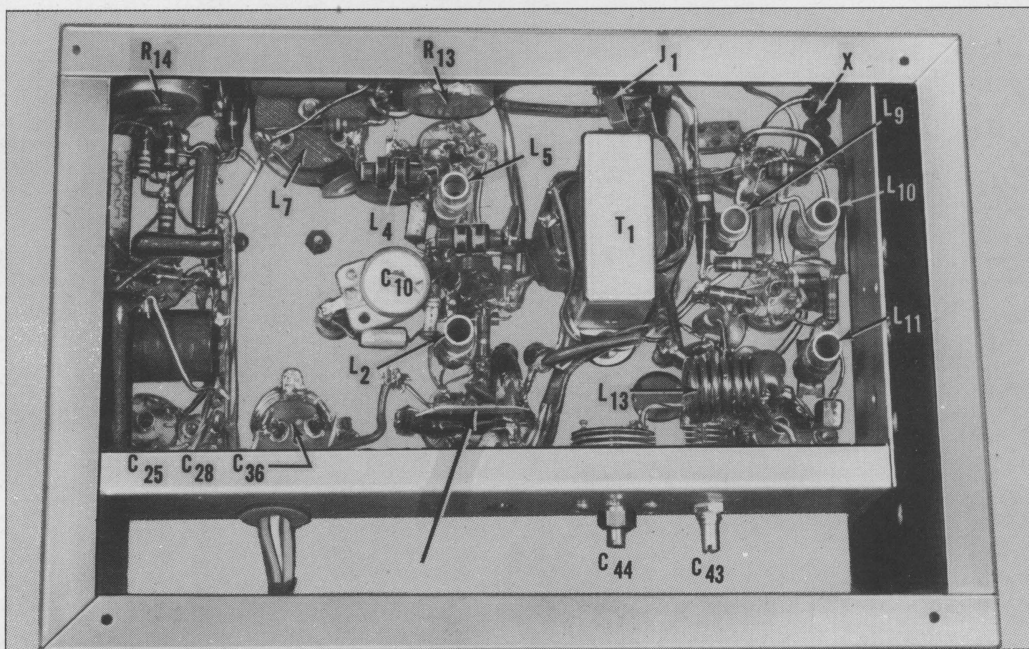


Fig. 3. Bottom view of the Twomobile. Note the accessibility of the components. Arrow points to a copper shield provided on the 6AK5 socket to prevent self oscillation of the rf amplifier.

the plate voltage to the oscillator and doubler tubes. A second set of relay contacts opens the voice-coil circuit of the speaker and grounds the cathode resistor of the 5763 doubler-final. Excitation for a carbon microphone is obtained from the cathode returns of the first two transmitter stages, and the microphone audio output is fed to the cathode of the 6AU6 audio amplifier. Only half of the primary of the push-pull output transformer is used during reception. During transmission, the plate current of the final flows through the other half of the winding. This arrangement tends to minimize the possibility of core saturation.

Transmitter

The oscillator employs the familiar tritet circuit using a 6AK6 and an 18-Mc crystal. In the Twomobile, frequency multiplication in any one stage is limited to doubling. An 18-Mc crystal was chosen because it is the highest-frequency crystal that is generally available at comparatively low cost.* Some suppliers do not keep 18-Mc crystals in open stock, but they can obtain them on special order, ground to any desired frequency. (The crystal used in this transmitter was received within two weeks from the time the order was placed.) A 12-Mc crystal, and tripling in the oscillator to 36 Mc, would possibly work satisfactorily, but driving power would be sacrificed. If this arrangement is desired, it is necessary to add a few turns to L₉.

The oscillator plate tank, L₁₀, is tuned to 36 Mc and is coupled to the 6AK6 doubler through capacitor C₃₄. In order to hold the capacitance appearing across the 72-Mc tank to a minimum,

*Some surplus 6-Mc crystals operate very satisfactorily as 18-Mc overtone units. This is especially true of the air-gap mounted type, the small plated variety usually having poor overtone capabilities.

a balanced coil is used. This circuit is equivalent to a conventional split-stator tank circuit in that the 6AK6 plate capacitance and the 5763 grid capacitance are equivalent to the respective sections of a split-stator capacitor. This balanced tank-circuit arrangement provides appreciably more drive to the final than would be available from an unbalanced circuit.

A 5763 doubler does an excellent job as the output power amplifier. Here too, a balanced tank is used; however, in this circuit the inductance is fixed and tuning is controlled by capacitor C₄₃. The capacitance of C₄₃ should be equal to the 5763 output capacitance. In practice, however, the coil is adjusted for a frequency as close to the center of the band as possible, with the capacitor set at approximately 7 $\mu\mu\text{f}$. Minor corrections and adjustments are then made with C₄₃. The choke L₁₂ permits small unbalances with negligible effect on the output.

Mechanical Considerations

The entire rig is built on an 8 by 4½ by 1½-inch chassis; it is housed in a 5 by 6 by 9-inch box. The photos clearly show the chassis layout. In Figs. 2 and 3, the transmitter occupies the right-hand side of the chassis and the receiver is located on the left-hand side. The 6AK5 rf stage is at the rear of the center row of tubes, the 12AT7 oscillator-mixer is the center tube in this row, and the 6C4 detector is in front. The 6AU6 is located to the left of the 6C4 and, from front to rear, the 6AQ5, followed by the voltage regulator. The oscillator tuning capacitor and coil are mounted on a bracket which is mounted between the 6AQ5 and the 12AT7. The leads (thin straps) from this tuned circuit connect to polystyrene feed-through insulators. A ceramic trimmer is mounted directly on the grid feed-through insulator. As a precau-

tion against self oscillation of the rf amplifier, a thin copper shield is soldered across the 6AK5 socket. This shield minimizes coupling between the input and output circuits. As in the construction of all vhf equipment, short, heavy ground and rf leads should be used.

The transmitter tube lineup starts with the 6AK6 crystal oscillator, located directly behind the front panel. This 6AK6 is followed by the 6AK6 doubler, and the 5763 doubler-final at the rear of the chassis. This layout places the antenna leads for both the transmitter and receiver close together at the rear of the chassis, thereby providing a convenient location for relay RL. The PA tank tuning capacitor and the series-link capacitor are mounted on the rear of the chassis as shown in Fig. 3, and are accessible through two holes in the back of the cabinet.

Ventilation and cooling of the unit is provided by rows of 1/4-inch holes at the top and bottom of the sides and back of the cabinet. To dress up the appearance of the Twomobile, the cabinet was painted with gray automobile touch-up lacquer, by means of an inexpensive spray gun which operates from the air pressure of a spare tire.

Previous experience with mobile equipment emphasized the importance of making sure that all mounting screws are tight. The constant vibration encountered on the road will loosen mounting hardware in a surprisingly short time. For this reason, it is recommended that lockwashers, "stop nuts," or other means be employed to keep the mounting screws tightened.

Except where specified otherwise, all coils are wound on 1/4-inch diameter, paper-base, slug-tuned forms. RCA Type 202L1 TV picture if coils (which are available at many supply houses) were used for this purpose after the original windings were removed. Other types may be substituted, but make certain that the cores are designed for high-frequency use.

Relay RL is shown in the schematic diagram as a three-pole, change-over relay; a four-pole relay is used in the Twomobile. Since relays are in critical supply at this time, it may be difficult to obtain a 6-volt dc, three-pole unit. If the required type is unobtainable, a single-pole and a double-pole combination, or two double-pole relays may be substituted for the three-pole relay. The other alternative is to rewind the coil of one of the many 28-volt relays that are plentiful in surplus. This modification is quite simple; e.g., for a conversion from 28 volts to 6 volts, the procedure consists of unwinding the coil and rewinding the form with wire which is six wire sizes larger.*

Alignment and Tuning†

Alignment of the Twomobile is comparatively simple. A grid-dip oscillator would be invaluable for this purpose but it is not absolutely necessary; the tuned circuits of the Twomobile can be easily adjusted with the aid of a wavemeter, an output indicator such as a crystal-diode, field-strength meter, signal source, and a 60-ma miniature lamp (pink bead) with a single-turn loop.

Receiver. Adjust the second detector to 11 Mc by varying the inductance of L_5 to where a wavemeter, tuned to this frequency and coupled loosely to L_5 , pulls the circuit out of regeneration.

(The frequency of the second detector may be checked more accurately with a communications receiver tuned to pick up the radiation from the detector.) The frequency of the oscillator should be checked with a wavemeter while trimmer capacitor C_{10} is adjusted. Set C_{10} so that the mid-range setting of the tuning capacitor corresponds to a frequency of 135 Mc. Connect a signal source to the antenna connector and peak the antenna trimmer, C_1 , and the grid and plate coils, L_1 and L_2 , for maximum output. (Adjust L_1 by squeezing or spreading the coil turns.)

To obtain maximum performance from the receiver, it may be necessary to employ some cut-and-try experimenting with the tap position on L_1 , the capacitance of the mixer injector capacitor, C_7 , and the quench-frequency network R_{10} — C_{16} .

Transmitter. The first step in the tuning procedure is the adjustment of the oscillator inductor, L_9 , to the point where the crystal oscillator starts oscillating. A receiver tuned to 18 Mc may be used as an indicator. Couple a single-turn loop with a 60-ma miniature lamp to L_{10} , the oscillator plate tank, and peak L_{10} for maximum output as indicated by the lamp brightness. Use a wavemeter to make sure that the plate circuit of the oscillator is tuned to 36 Mc rather than to a higher harmonic. Follow this procedure in tuning L_{11} , the doubler plate tank, to 72 Mc. Using the field-strength meter, tune the output tank to resonance by varying capacitor C_{43} , and adjust C_{44} , the output trimmer for maximum output. Alternately readjust C_{43} and C_{44} until the output is peaked as high as possible. Finally, go backward through the alignment procedure and peak each circuit for maximum output.

The transmitter is now ready for operation—happy Twomobiling!

THERE'LL BE AN RCA 6146 IN YOUR NEW RIG!

We're sure of that—and you'll agree after reading the ad on the back cover of this issue of HAM TIPS!

Old timers will remember the popularity of the old 210 and the 46's. Then, the 807 became the amateur's favorite.

Our prediction is that the new RCA 6146 will be even more popular; check the ratings (given in the ad) again and you'll agree! Probably you'll start drawing up a circuit for a trim 2-meter final using the new 6146. Whether your next project is a de luxe all-band exciter, or a powerful little rig to back up that new WN call, it will be a better rig if it's built around the sensational 6146.

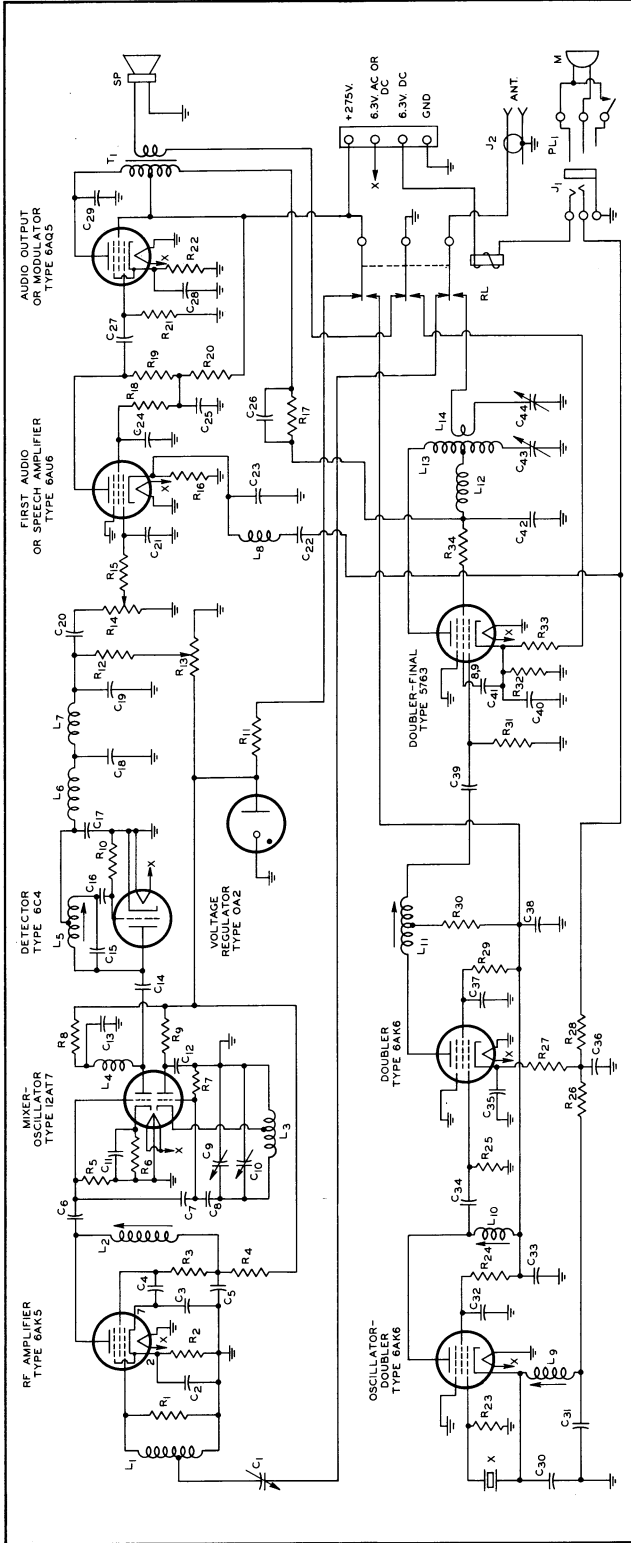
We have wonderful plans for our new baby! To start the ball rolling, a novice transmitter with an RCA 6146 final will be featured in the next issue of HAM TIPS—don't miss it!

We expect that RCA Tube Distributors will have this new tube in stock shortly after the middle of January.



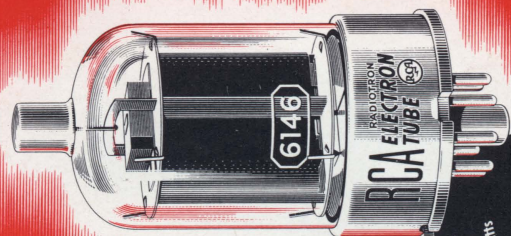
*"Converting D-C Relays," by R. B. Tomor, W1PIM, Radio News, December, 1948.

†The antenna should be connected during alignment.



- RF AMPLIFIER**
TYPE 6AK5
- MIXER-OSCILLATOR**
TYPE 6X4
- DETECTOR**
TYPE 6C4
- FIRST AUDIO AMPLIFIER**
OR SPEECH AMPLIFIER
TYPE 6AU6
- AUDIO OUTPUT OR MODULATOR**
TYPE 6AQ5
- OSCILLATOR-DOUBLER**
TYPE 6AK6
- DOUBLER**
TYPE 6AK6
- DOUBLER-FINAL**
TYPE 6Y6
- NOTE**
All resistors 1/2 watt unless specified otherwise.
- RF** 10,000 ohms.
R1, R3, R7 220 ohms.
R2, R30 1,000 ohms.
R4, R6, R9, R9 1 megohm.
R5, R10 820,000 ohms.
R11 5,000 ohms, 10 watts.
R12, R20 27,000 ohms.
R13 250,000 ohms, potentiometer, 1 watt.
R14 2,000 ohms, 1 watt.
R15, R16 1,200 ohms, 1 watt.
R17 390,000 ohms.
R19 470,000 ohms.
R21, R22 820 ohms.
R23 470,000 ohms.
R24, R29 22,000 ohms.
R26, R27 120 ohms.
R28 390 ohms.
R33 68 ohms.
R34 12,000 ohms, 1 watt.
SP 4-in., p.m. speaker.
T1 4-watt output transformer, pp plates to voice coil (Merit A-2900).
X 18-Mc crystal.
- L1** 4 turns No. 16 enam., 3/8-in. diam., spaced to over-all length of 3/4 in., tapped 1 turn up from ground end.
L2 3 turns No. 28 d.c.c., spaced to over-all length of 1/2 in.*
L3 3 turns No. 12 enam., 1/2-in. diam., spaced to over-all length of 1 in., tapped 1 turn from ground end.
L4, L6 Choke, 100 μh (National R-33).
L7 22 turns No. 28 d.c.c., close wound, center tapped.*
L8, L12 Choke, 80 mh (Weissner 19-486).
L9 Choke, 144-Mc (Ohmite Z-144).
L10 7 turns No. 28 d.c.c., close wound.*
L11 10 turns No. 28 d.c.c., close wound, center tapped.*
L13 6 turns No. 16 enam., 1/2-in. diam., spaced to over-all length of 1/4 in., center tapped.
L14 1/2-turn link, No. 16 enam., interwound in center of L13.
- M** Single-button, carbon microphone.
PL1 3-circuit microphone plug.
RL 3-pole, double-throw, 5-5 dc relay (Patt & Brumfield KR-14D).
- C1, C10** 4-30 μmf, ceramic trimmer (Erie TS2A, N500).
C2, C3, C4, C5 1,000 μmf, ceramic (CRL disc Hi-Kap).
C11, C12, C13, C35 22 μmf, ceramic (CRL tubular Hi-Kap).
C24, C25, C26, C37, C38 1-in. length of 70-ohm twin lead (lanes removed).
C6, C8, C7 2-plate, midget variable (Millen 20015, C9)
C15 30 μmf, mica (El-Menco CM-15).
C16, C34, C39 56 μmf, mica (El-Menco CM-15).
C17, C18, C19, C27 0.01 μf, paper.
C20 10 μf, electrolytic, 50 vv. All mica and paper capacitors should have a rating of at least 50 vv.
C22, C23 Triple-unit electrolytic:
C25 10 μf, 350 vv.
C28 20 μf, 50 vv.
C36 20 μf, 50 vv.
C39 3,000 μmf, ceramic (CRL tubular Hi-Kap).
C40 100 μmf, mica (El-Menco CM-15).
C42 2,000 μmf, mica (El-Menco CM-15).
C43 14 μmf, midget variable (Johnson 15M11).
C44 25 μmf, midget variable (type APC).
J1 3-circuit microphone jack.
J2 Coaxial connector, UG-2900.
- *Wound on 1/4 in. diam., slug-tuned form (from RCA 20211 picture if coil).

New! RCA-6146



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Development is RCA

MAXIMUM ICAS* RATINGS

Below 60 Mc At 150 Mc

435 volts
130 ma
65 watts

750
150
90

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Plate current
Plate input

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125 ma
48 watts

600
125
67.5

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Another RCA advance in Beam Power Tube design

Here's a power tube that will outperform anything in its class. Rated to 175 Mc—only a tube larger than a 2E26—the new RCA-6146 beam power tube is tailor-made for the amateur 2-meter band.

Rated at a heater voltage of 6.3 volts and current of 1.25 amperes, the RCA-6146 can deliver a CW output (ICAS) of approximately 69 watts at frequencies up to 60 Mc. At 150 Mc, the CW output (ICAS) is approximately 35 watts or better. An RCA-5763 or an RCA-2E26 is an excellent driver for this trim powerhouse.

It goes without saying that the new RCA-6146

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