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ULTRA-HIGH-FREQUENCY TELEVISION CONVERTERS

RADIO CORPORATION OF AMERICA
RCA LABORATORIES DIVISION
PRINCETON N.J.

2041

Ultra-High-Frequency Television Converters

SEPTEMBER 1, 1948

RCA LABORATORIES DIVISION

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Introduction

This is a description of two television converters developed at the RCA Laboratories for experimental use in the reception of the field-test transmissions in the 500-Mc region to be made by RCA in the Washington, D. C. area this fall. The converters are intended for operation with standard television receivers.

The Model A converter has a tuning range of 480 to 800 Mc while Model B has a tuning range of 480 to 600 Mc. Both have self-contained power supplies and convert ultra-high-frequency television signals to television Channel 3 on 60-66 Mc.

The designs are presented here in order that those who care to do so may duplicate the construction and make their own observations of the 500-Mc test transmissions. These converters were designed solely for field test purposes. Their oscillator radiation and spurious response characteristics would probably make them unsatisfactory for other uses. Generally available standard components and tubes are used.

Model A

Figs. 1a, 1b and 1c are photographs of the Model A converter. The circuit diagram is shown in Fig. 2. As can be seen the input tuned circuit consists of a capacity-loaded resonant transmission line. This line consists of a pair of brass rods grounded through short brass bars. The loading capacitor consists of a brass slider which is insulated from the brass rods by polystyrene sleeves. Tuning is accomplished by moving the slider back and forth. The low-frequency position is with the slider at the open end of the rods.

The 6F4 oscillator is tuned in a similar manner to the antenna circuit. The actuating mechanism in both cases is a string drive which also rotates the dial. Construction of input and oscillator tuning lines is shown in Fig. 3.

The mixer is a crystal detector 1N21B. A terminal board marked "OSC. B+ CURRENT" with a shorting link is supplied so that an oscillator plate current meter can be connected in the circuit. This current should run between 10 and 20 milliamperes. A similar terminal board marked "XTAL CURRENT" is supplied for a meter to read d-c crystal current. This current should run between 0.25 and 1.0 milliamperes for best operation. However, it sometimes varies unavoidably over wider limits in tuning over the complete frequency range. The magnitude of the crystal current may be adjusted by bending a brass strap connected to the crystal i-f lead, toward or away from the oscillator socket.

The crystal mixer is followed by a 6AK5 operating as a grounded-cathode triode and by a 6J4 operating as a grounded-grid triode.* This amplifier has a gain of 12 and a pass band of

*This circuit is described by H. Wallman, A. B. Macnee and C. P. Gadsden, "A Low-Noise Amplifier", *Proc. IRE*, vol. 36, pp. 700-708; June 1948.

Fig. 1a – Front view of Model A converter.

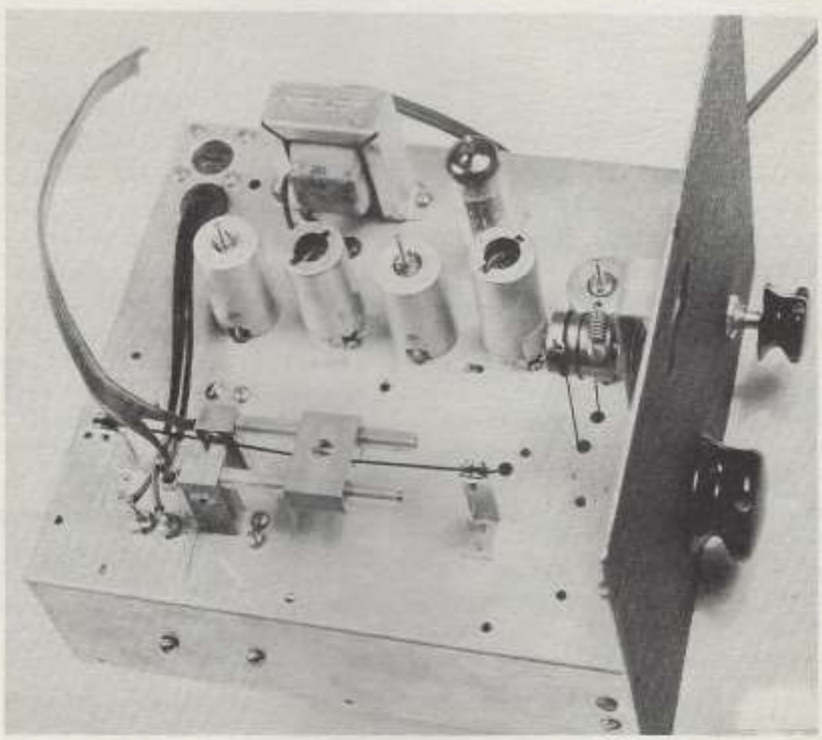


Fig. 1b – Top view of chassis of Model A converter.

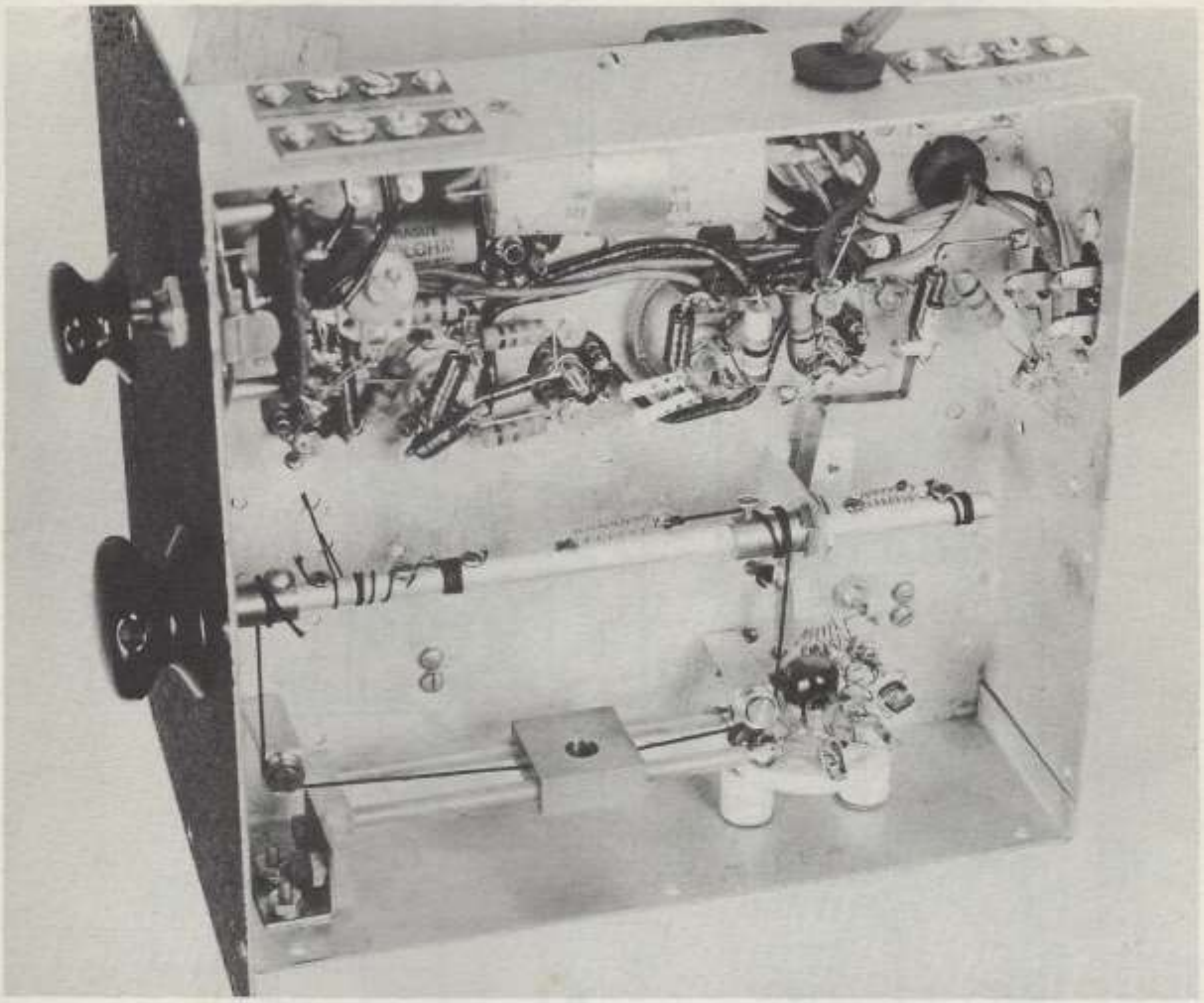


Fig. 1c — Bottom view of chassis of Model A converter with oscillator shield removed.

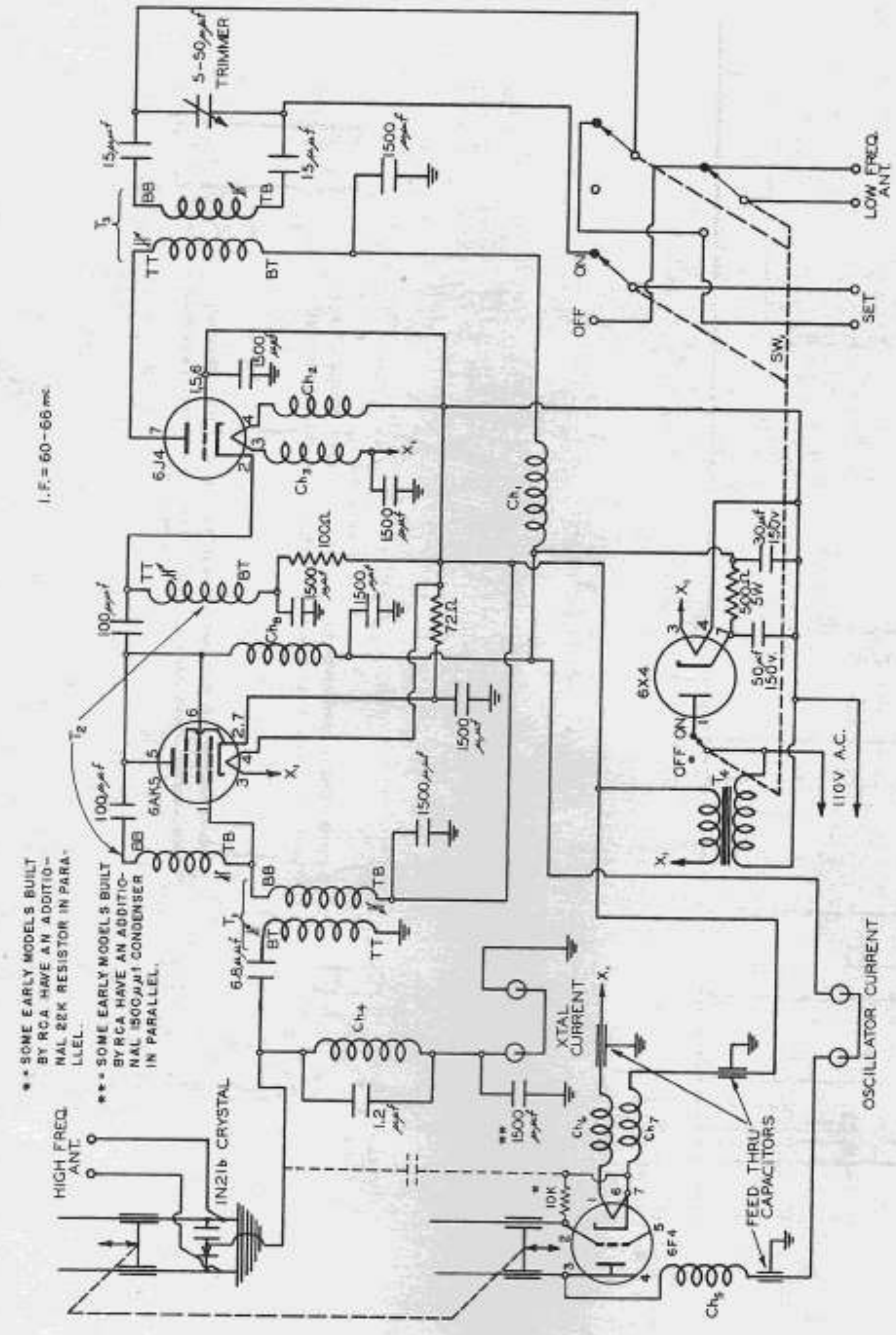
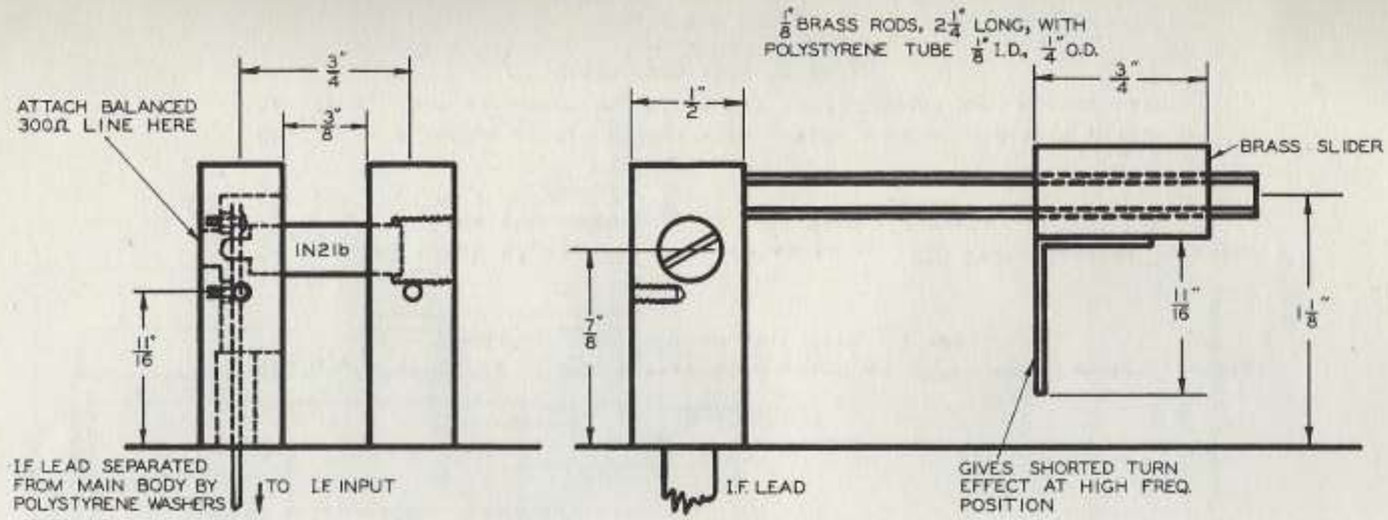
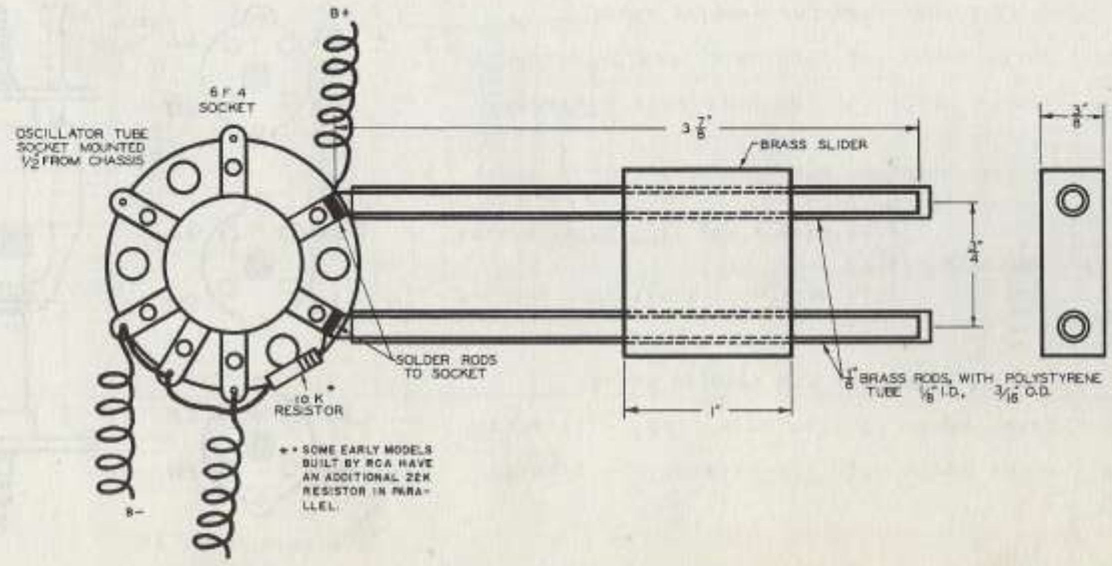


Fig. 2 - Circuit diagram of Model A converter.

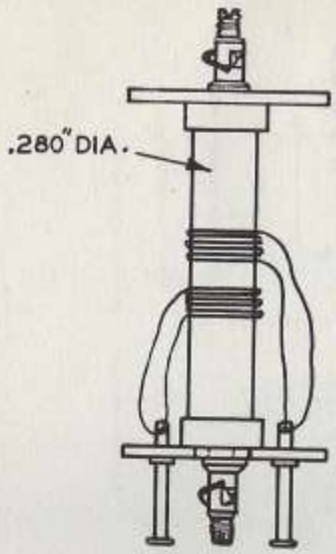


a - Antenna tuning mechanism.

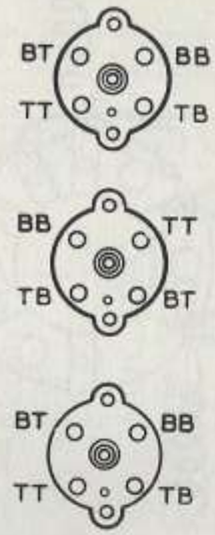


b - Oscillator tuning mechanism.

Fig. 3 - Antenna and oscillator tuning mechanism, Model A converter.



Bottom View
of Transformers



T_1: Primary - (Top winding): 10T close wound - #24 Formex wire
Secondary - (Bot. winding): 8T close wound - #24 Formex wire
Space primary and secondary 3/32 inch.

T_2: Peaking inductance (Top winding):
6T close wound - #24 Formex wire
Neutralizing coil (Bot. winding):
10T close wound - #32 Formex wire
Space primary and secondary 1/2 inch.

T_3: Primary - (Top winding: 10T close wound - #24 Formex wire
Secondary - (Bot. winding): 10T close wound - #24 Formex wire
Space primary and secondary 3/32 inch.

TT = Top of top winding
BT = Bot. of top winding
BB = Bot. of bot. winding
TB = Top of bot. winding

Chokes

$Ch_{1,4,8}$ - 48 turns of #32 Formex wire wound on .225 inch diameter resistor (resistor used only as coil form - 1 meg.)

$Ch_{2,3}$ - 48 turns of #32 Formex wire wound on .225 inch diameter resistor (resistor used only as coil form - 1 meg.)

$Ch_{5,6,7}$ - 8 inches of #26 Formex wire - wind wire on 1/4-inch circular form, then remove form. Coils are self-supporting. Approximate dimensions when in air:
O.D. ≅ 0.28 inch
Length ≅ 3/8 inch with 1/2 inch pigtails

Fig. 4 - Detailed construction of transformers and chokes, Model A converter

60 to 66 Mc. The detailed construction of the transformers and r-f chokes is shown in Fig. 4. The conventional power-supply circuit employs a 6X4 rectifier tube.

Model B

In the design of the Model B converter, simplicity was considered of prime importance. This model uses two 6J6 tubes and a selenium rectifier. The r-f circuits are fixed-tuned and are sufficiently broad to include the 480-600 Mc band.

Referring to Fig. 5, it may be seen that cathode input is used for the r.f. in the mixer stage, while grid injection is used for the oscillator. The two halves of each 6J6 are operated in parallel to reduce lead inductance. The gain of this converter is about unity.

Fig. 6a shows a front view of a Model B unit in its case, while Fig. 6b is a top view of the chassis with the case removed, showing the layout of parts and the anti-microphonic tube shields. Fig. 6c is a view of the chassis from the bottom showing the wiring. The cover shown to the side of the chassis normally fits over the oscillator compartment. The string drive mechanism shows clearly in this photo-

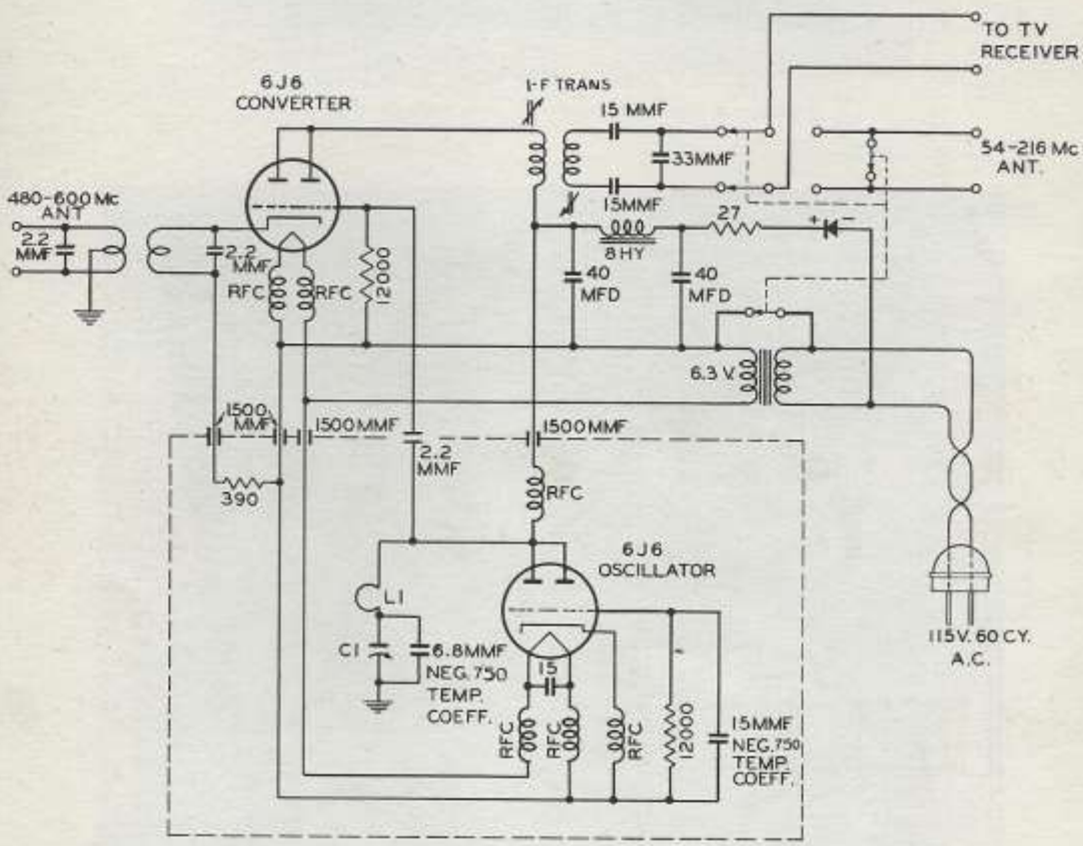


Fig. 5 - Circuit diagram of Model B converter.

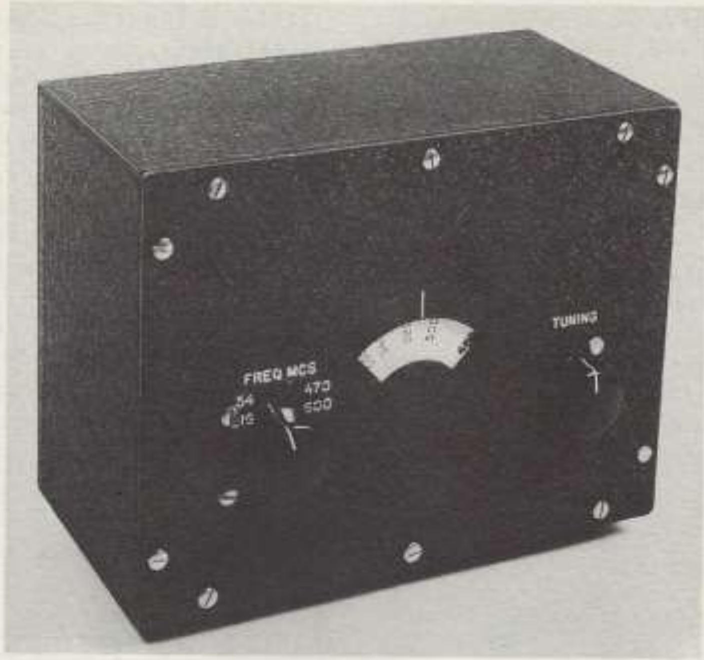


Fig. 6a - Front view of Model B converter.

Fig. 6b - Top view of chassis, Model B converter.

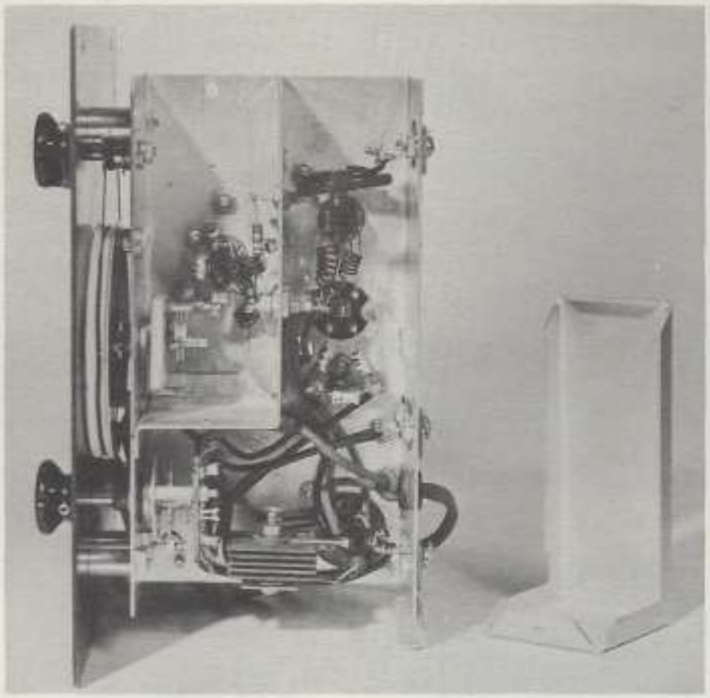


Fig. 6c - Bottom view of chassis, Model B converter.

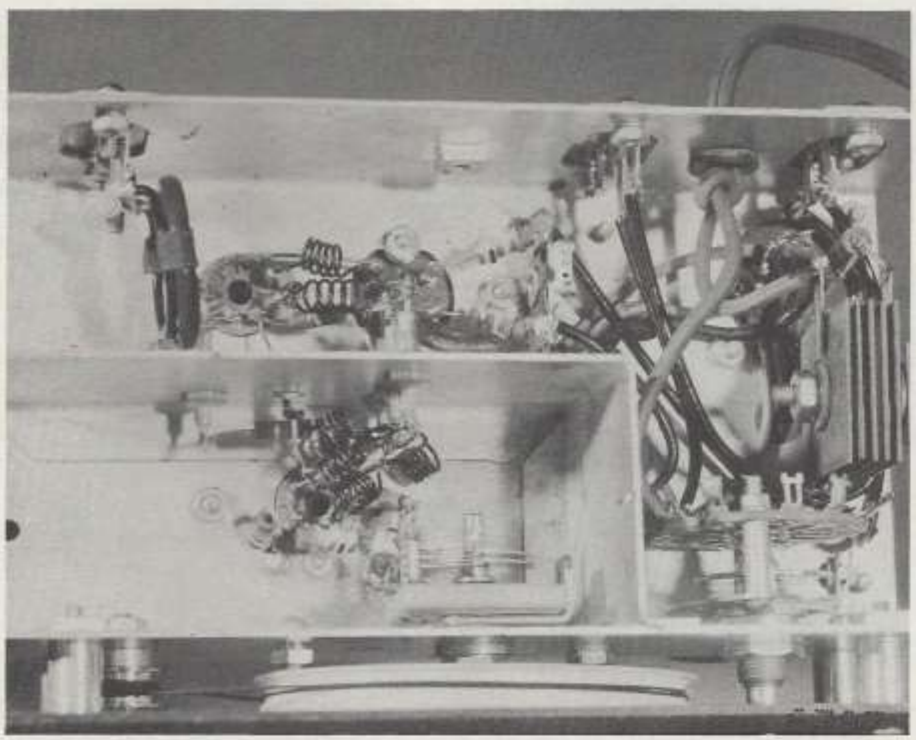


Fig. 6d - Bottom view of chassis, Model B converter, showing detail.

graph. Fig. 6d is a closeup view which shows more clearly the wiring details. The location and lead lengths of the oscillator circuit capacitors are critical. A portion of the 5/32-inch wide strap which forms the oscillator plate tuning inductance is shown. Below it can be seen the ungrounded end of a small ceramic capacitor. Changing the position of this capacitor adjusts the upper frequency of the oscillator.

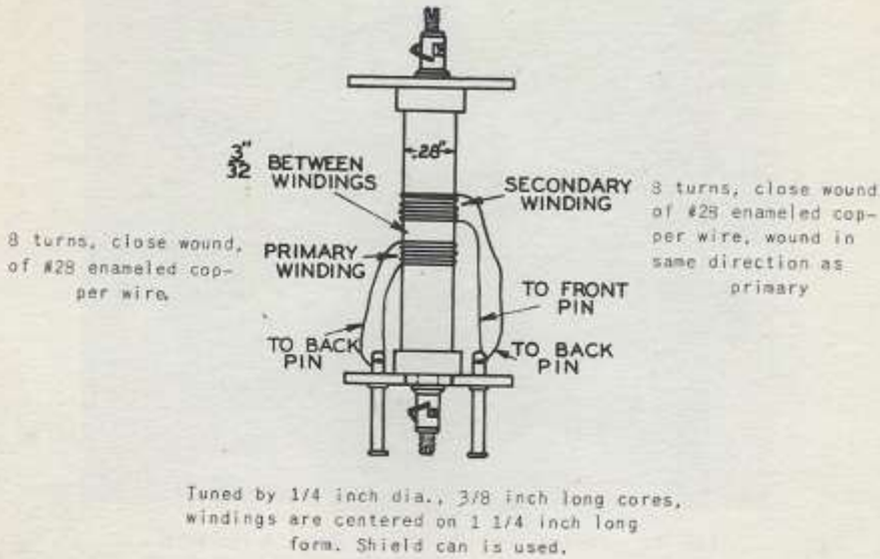
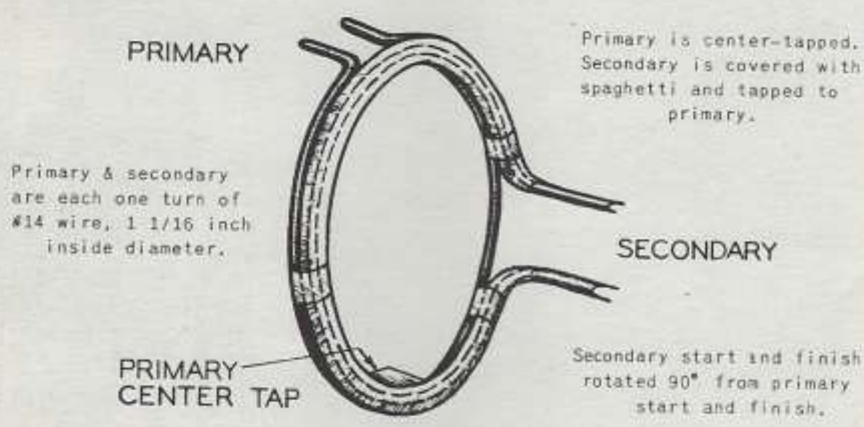


Fig. 7a - Detailed construction of transformer, Model B converter.



R-F Chokes: 5 turns #24 wire space wound one turn. 3/16 inch I.D.

Oscillator inductance: 5 mil. copper strap 1 inch long by 5/32 inch wide.

Fig. 7b - Detailed construction on input circuit, Model B converter.

A double-tuned 60-66 Mc transformer follows the converter. It may be retuned for 54-60 Mc operation where it is desired to use Channel 2 on the television receiver instead of Channel 3. Data on the construction of the r-f and oscillator inductances, 60-66 Mc transformer and r-f chokes are given in Fig. 7b.

Because there is about 0.006μf of a capacity between the B- lead and chassis it is possible to obtain a small spark between chassis and ground with the a-c plug in one position.

Noise Factor

The noise factor of the converters at 500 Mc operating with RCA receiver 8TS30 is:

Model A 10 db above thermal.
Model B 22 db above thermal.

Oscillator Radiation

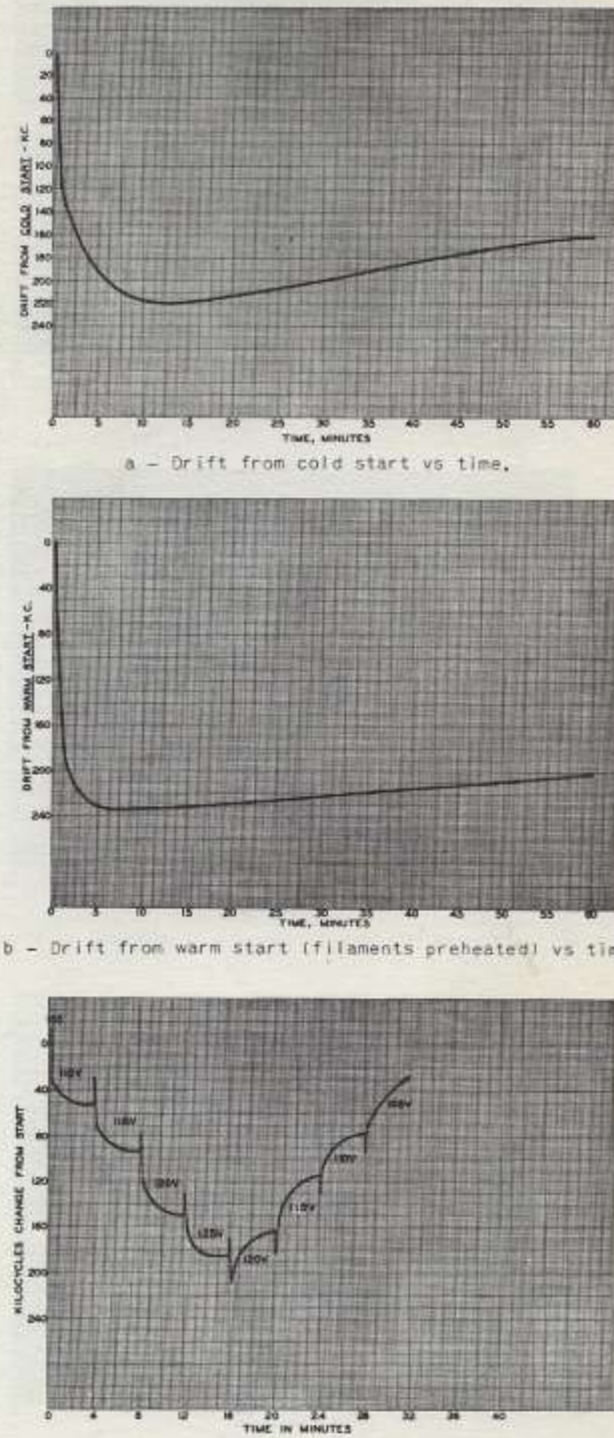
In a practical installation with a 50-foot 300-ohm standard transmission line and a dipole antenna, the radiation originating from the local oscillator in the converters at 450 Mc will be such as to cause the following potentials to appear at the input terminals of a receiver fed from a like transmission line and antenna spaced 100 feet away:

With Model A converter about 150 microvolts.
With Model B converter about 9,000 microvolts.

Oscillator Stability

The data presented here were taken on one each of the converters so they may not represent the average characteristics for these converters. Figs. 8a, 8b and 8c give the frequency stability characteristics as obtained on one Model A converter. Figs. 9a, 9b and 9c give the frequency stability on one Model B converter. The curves in Figs. 10a and 10b were taken with the same Model B converter but with a different oscillator tube.

Power-line hum frequency modulation of the local oscillator causes hum in the audio output about 33 db below maximum signal modulation at 500 Mc on both types of converters.

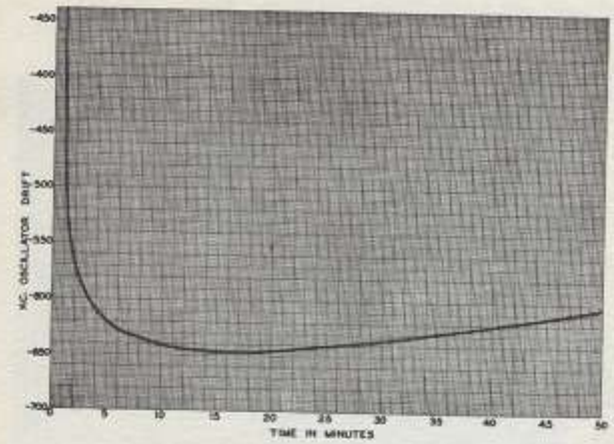


a - Drift from cold start vs time.

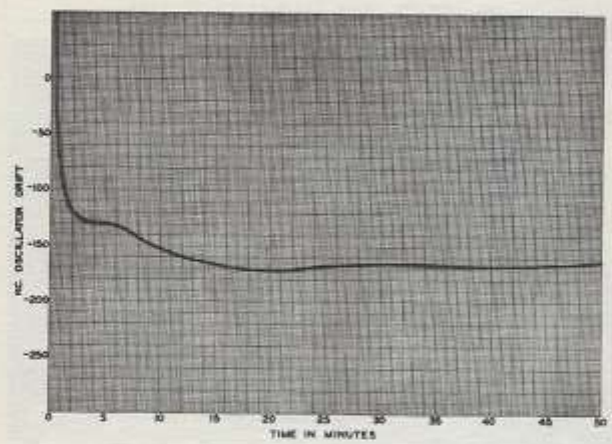
b - Drift from warm start (filaments preheated) vs time.

c - Effect of change in line voltage on frequency stability.

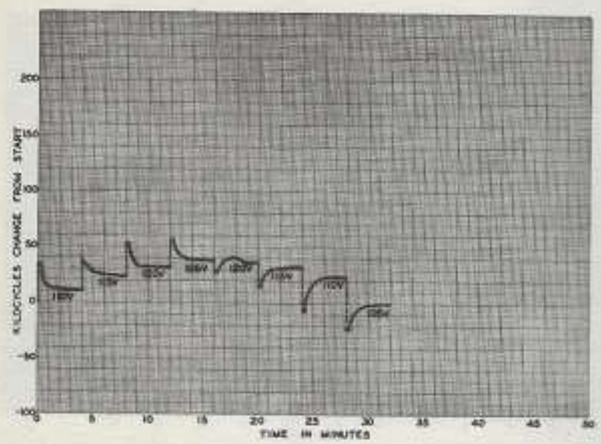
Fig. 8 - Oscillator stability characteristics, Model A converter.



a - Drift from cold start vs time.

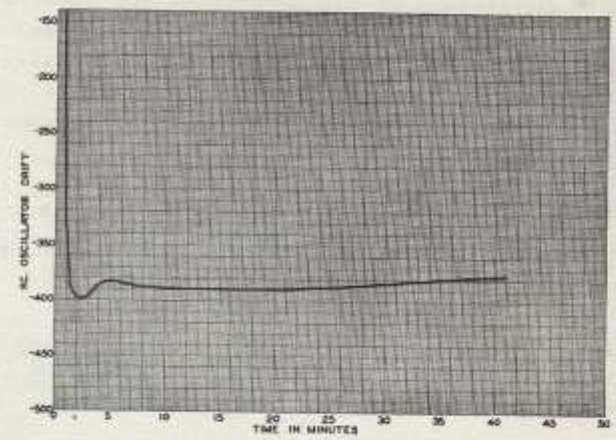


b - Drift from warm start (filaments preheated) vs time.

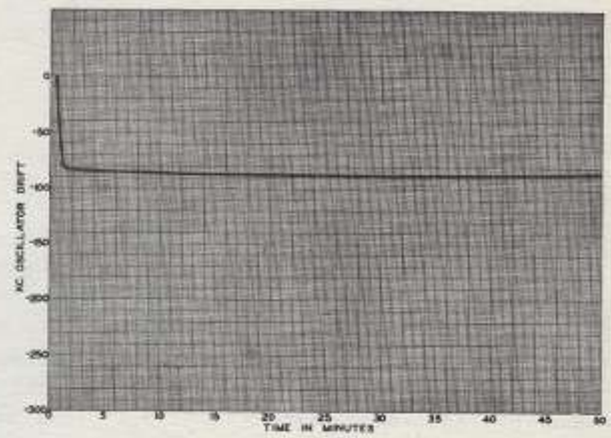


c - Effect of change in line voltage on frequency stability.

Fig. 9 - Oscillator stability characteristics, Model B converter.



a - Drift from cold start vs time.



b - Drift from warm start (filaments preheated) vs time.

Fig. 10 - Oscillator stability characteristics of Model B converter with a different tube.

Spurious Responses

When operating the Model B converter with a television receiver having a 21.25-Mc sound i.f., a heterodyne beat will be heard when receiving signals on 522 Mc and 566.5 Mc. These responses are created by mixing the 5th or 6th harmonic of the television receiver's local oscillator at 87 Mc with the converter local oscillator at 456.25 Mc or 500.75 Mc. These spurious responses have an amplitude equal to a 400-microvolt input signal.

These same spurious responses occur when operating with the Model A converter. Their amplitude is equal to a 70-microvolt input signal. Other responses will be observed at alternate intervals of 42.5 and 44.5 Mc throughout the tuning range.

A low-pass filter in the transmission line link between converter and television receiver will substantially reduce these objectional responses. For example, a 4-inch open-ended stub of the standard transmission line connected across the converter output terminals will reduce the 522 Mc and 566.6 Mc responses by a factor of 3.

Installation

The input terminals marked "HI ANT." should be connected to a 300-ohm balanced transmission line leading to a suitable u-h-f antenna. The output terminals marked "SET" should be connected to a similar 300-ohm line leading to a television receiver. The input terminals marked "LO ANT." should be connected to a 300-ohm balanced line leading to a suitable antenna for the 54-216 Mc range. The power cord should be connected to a source of 115 volts, 60 cycles.

A strong television signal on Channels 2, 3 or 4 may in some installations cause interference to reception in the 500-Mc band. This usually can be avoided by taking care to see that the transmission lines leading to the converter are well separated, so as to reduce capacity coupling. In some installations it may be necessary to disconnect the low-frequency antenna line from the converter and place a high pass filter in the high-frequency antenna line.

Operation

A switch is provided on the converters for changing from reception in the 500-Mc band to reception in the standard television bands. For reception in the high-frequency band the switch should be set to the position marked 470-800 Mc or 470-600 Mc.

The television receiver should be tuned to television Channel 3. The controls of the television receiver should all operate in the normal manner.

When the frequency band switch is in the position marked "54-216 Mc" the antenna for that band is connected straight through to the receiver so that the receiver should operate in the normal manner. In this position the switch cuts off the converter B supply but not the filaments. Thus, rapid switching may be used for comparison purposes. To cut off the filament current of the tubes in the converters, it is necessary to pull the wall plug.