Bibliography

Eddy, Myron F. Aeronautic Radio. New York: The Ronald Press Company, 1939, pp.302-307.
Morgan, Howard K. Aircraft Radio and Electrical Equipment. New York: Pitman Publishing Corporation, 1939, pp. 144-151.
Terman, Frederick E. Radio Engineering. New York: McGraw-Hill Book Company, 1937, pp. 526-527.

Western Electric Aircraft Transmitter No. 13C

Western Electric radio equipment of one kind or another is in use on most of the major airlines and many of their connecting lines where modifications have in some cases been successfully incorporated. The Bell Telephone Laboratories design and develop W.E. sets.

In presenting descriptions of a specific model, it is felt that the studious reader will acquire practice in analyzing the electrical action within circuits and gain a detailed knowledge of the various circuits.

Where a schematic diagram of a circuit is given, this can be referred to in connection with operating, installation, and adjustment instructions issued by the manufacturer and available wherever a W.E. set is installed. Students, operators, and pilots are advised to go over some W.E. radio installation with an attendant operator or competent instructor, learning how to operate both transmitters and receivers. In the meantime refer to Figure 127.

The No. 13C radio transmitter is a light, compact radiotelephone transmitter developed by Bell Telephone Laboratories for use in Western Electric communication systems. It provides facilities for three carrier frequencies, any one of which may be selected by means of a single mechanical control which may be extended to a remote point if desired. The transmitter contains antenna tuning equipment of ample flexibility to permit efficient adjustment for a wide variety of antennas, and also contains a remotely controlled antenna relay.

More than 50 watts of carrier power are delivered to the antenna circuit by the last radio-frequency amplifier stage in this transmitter. If the antenna has a resistance greater than about 4 ohms, approximately 50 watts will be delivered to the antenna itself. The transmitter is quartz-plate controlled and will maintain the carrier frequency within 0.025%. It is capable of substantially complete modulation.

The high-voltage supply for the transmitter may be a dynamotor or other source capable of furnishing 0.350 amperes at 1050 volts d.c. Neither side of the supply can be grounded. The commutator ripple is attenuated by the filter choke L11 and condensers C17 and C19. The negative side is connected through resistor R7 to ground, the voltage drop across this resistor being used for grid bias. The positive high voltage is routed through a vacuum type relay (S5) which closes the circuit when the antenna relay is operated. Voltage dividing resistors, (R10, R9, and R8), furnish reduced plate voltage for the No. 205D vacuum tubes and screen bias for the No. 282A vacuum tubes.

Communication systems using this transmitter are arranged for push-button control. A button is pressed while transmitting and released while receiving, all switching operations being performed by relays. In the transmitter, S4 is the control relay. The positive 12-volt supply to this relay is routed through switch D1. D1 is arranged to prevent energizing S4 unless the frequency-change switches are centered on one of the three operating positions; it also furnishes 12 volts to terminal 12 when it is off-position to operate a remote signal. D9 is a safety switch on the transmitter cover to protect the operator while he is adjusting the tuning coils. It is connected in series with the coil of the high-voltage relay S5. When the microphone button is pressed, grounding terminal 7 or the tip of the microphone jack (J11), the control relay closes two sets of contacts. One contact operates the antenna relay (S6) and also places 12 volts on terminal 8, which is used to start the dynamotor. The other contacts close the microphone circuit and connect the speech input to the audio amplifier in proper sequence. The high-voltage relay (S5) is operated by a contact on the antenna relay and drops out as soon as the microphone button is released. This sequence of operation protects the antenna relay contacts from arcing. The copper oxide rectifier (Y4) prevents sparking at the contacts of the control relay.

In the following description the numbers in parentheses refer to apparatus designations on the schematic, Figure 127.

Radio-Frequency Circuits. The quartz plates, interstage transformers, and antenna tuning coils and condensers are all plug-in units. Space is provided for three complete sets of this apparatus, any one of which may be selected for use by a single mechanical control operating a ganged switch. The transmitter may therefore be set up for any three frequencies within its range, each of which is immediately available for use.

The radio-frequency circuits in the transmitter consist essentially of a quartz-plate controlled oscillator and two stages of radio-frequency amplification. The quartz plate oscillates at one-half the desired output frequency and is connected in the grid circuit of the No. 205D vacuum

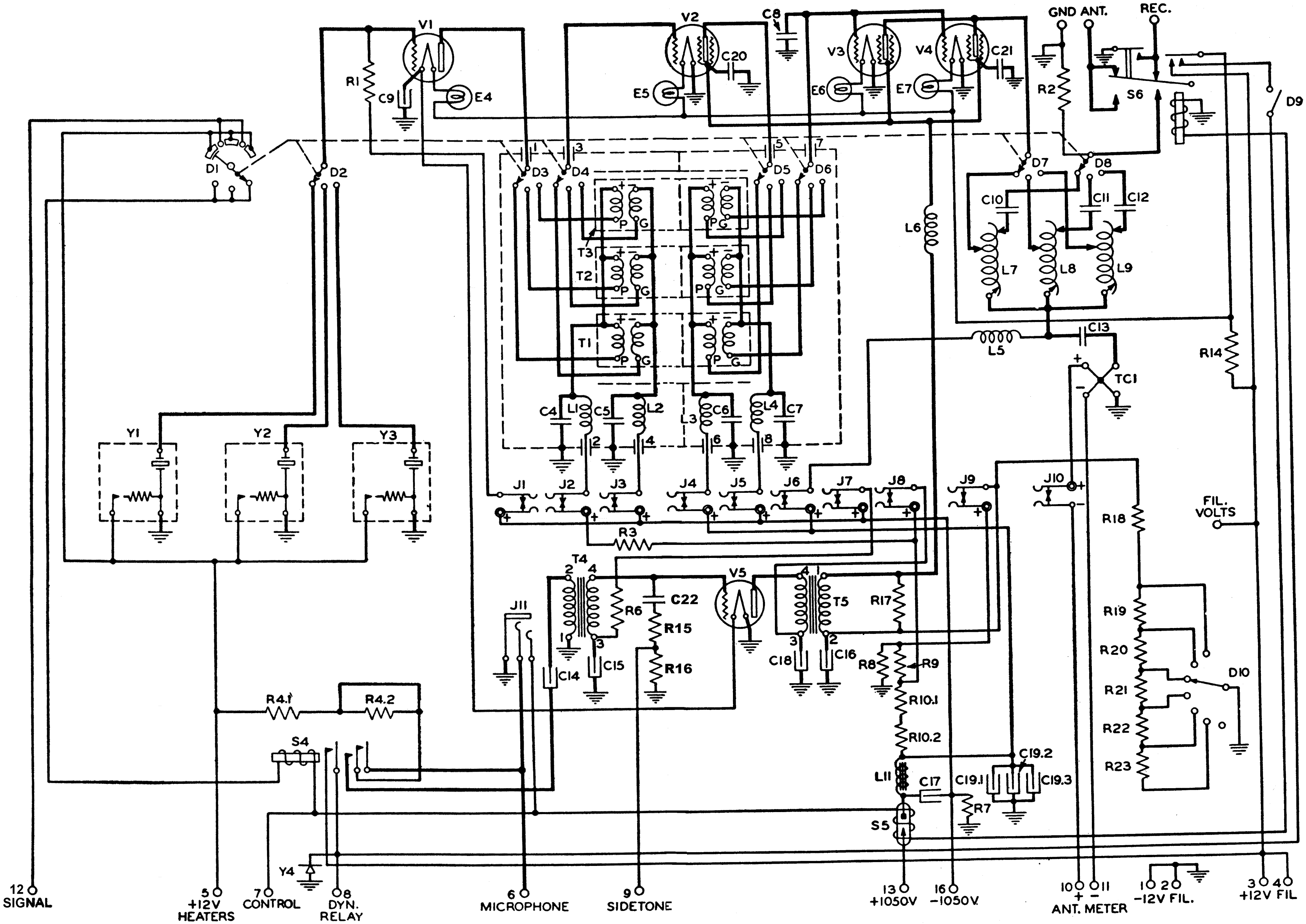

Figure 127. Schematic Diagram of Aircraft Transmitter No. 13C

tube (VI) used as the oscillator. The oscillator is coupled to the first amplifier by means of a radio-frequency transformer which in conjunction with the tube and wiring capacities forms a band-pass filter. The primary of this transformer presents a high inductive reactance to the plate of the oscillator tube at the quartz plate frequency and thus causes the No. 205D tube to oscillate. As this transformer freely passes the second harmonic of the quartz plate frequency, it drives the first amplifier at the output frequency, or twice the quartz plate frequency.

The first amplifier is a No. 282A vacuum tube (V2) and is coupled through another radio-frequency transformer to the grids of the second amplifier. This transformer in conjunction with condenser C8 and the stray capacities also forms a band-pass filter which freely passes the output frequency and drives the second amplifier.

For convenience, the two radio-frequency transformers are mounted together as a single plug-in unit (T1, T2, or T3) and designated a No. 271 type input transformer. The band of output frequencies over which the transformer will operate is given on the nameplate.

The second amplifier consists of two No. 282A vacuum tubes (V3 and V4) connected in parallel. The plate circuit of these tubes is coupled to the antenna by means of a No. 7A, 7B, or 7C tuning coil (L7, L8, or L9) and an antenna series condenser.

Audio-Frequency Circuits. The No. 13C radio transmitter contains a single stage of audio-frequency amplification using a No. 205D vacuum tube (V5). The microphone series resistor (R4) and stopping condenser (C14) are included in the transmitter. R4 is in two sections, one of 500 ohms and the other of 1595 ohms. For use in quiet locations (ground stations, boats, etc.) the large section can be short-circuited to increase sensitivity if desired. The stopping condenser prevents direct current from flowing in the input transformer (T4) and also modifies the frequency characteristic to a more desirable form when intense low-frequency noise is present.

The output of the audio amplifier is passed through transformer (T5) and modulates the screen bias on the first and second radio-frequency amplifiers. The resistor (R17) across the transformer secondary stabilizes the load on the audio tube and thereby improves the speech quality.

Power Supply and Control Circuits. The low-voltage circuits in the No. 13C radio transmitter are arranged to operate on a 12-volt storage battery supply, the negative side of which may be grounded. The filament current is approximately 10.6 amperes, and the maximum

current demand from the battery is about 15 amperes. A series resistor (R14) in the filament circuit permits the tubes to heat under reduced current when the external filament switch is closed. The filament resistor is short circuited by the antenna relay, bringing the tubes up to normal current during the actual transmitting interval.

The filament of each No. 282A vacuum tube is in series with an individual No. 112A ballast lamp (E5, E6, or E7). The tips of these ballast lamps are painted red for identification and the corresponding sockets in the transmitter are marked with a red dot. The filaments of the two No. 205D vacuum tubes are in series with a No. 113A ballast lamp (E4) which is identified by a green tip. The socket for this lamp is marked with a green dot.

The three quartz plates (Y1, Y2, Y3) employ crystals with very low temperature coefficients. No heating is required with ambient temperatures down to zero Centigrade. The No. 5A quartz plate may be used where the temperature never drops below zero. The Nos. 5B and 5C quartz plates may be used interchangeably in installations where lower temperatures are encountered. They contain a thermostat and heater which operates automatically to maintain the crystals above zero.

13C and 13CB Western Electric Transmitters—

Power output: 50 watts
Frequency range: 2000 to 6500 KC, 13CB covers 325 to 500 KC also.
Type frequency shift: Mechanical remote through geared tachometer shaft.
Number of frequencies: 3 non-related
Power supply voltage: 12 volts
Power consumption—standby: 6 amperes, approximately
Power consumption—modulated: 65 amperes, approximately

Tube types: Oscillator 205D, Doubler 282A, Power Amplifier (2) 282A, Modulator 205D, Ballast Lamps (1) 113A, (3) 112A
(All tube types are Western Electric)

	HEIGHT	WIDTH	DEPTH	WEIGHT
Transmitter (with mount)....	$10\frac{1}{8}''$	$13\frac{3}{4}''$	$21\frac{3}{4}''$	40 lbs.
Coils and crystals per channel........				2.5 lbs.
Same for low frequency channel (13CB)........				3.25 lbs.
13CB loading coil........				5.1 lbs.

The 13C transmitter is a three frequency transmitter. The 13CB transmitter is a modification which will allow operation of one or more channels in the band from 325 to 500 kilocycles and also provides for keying for continuous wave transmission.

The transmitters utilize a crystal oscillator tube, followed by a doubler which is used in all cases and excites the output stage consisting of a pair of Western Electric 282A tubes. The crystal frequency is half the carrier frequency except in the 300 to 500 kilocycle band. The screen grids of the doubler and final tubes are all modulated together. Fig. 86 shows the schematic of the 13C transmitter, Fig. 87 shows a modification for one airline's service.

No tuning, except the output antenna coupling transformer, is required for this transmitter. The correct interstage transformer must be plugged in to the interstage receptacles. The interstage transformers that can be supplied are:

NUMBER, WESTERN ELECTRIC	FREQUENCY RANGE KILOCYCLES
271K	300 to 500
271C	2250 to 2800
271B	2800 to 3500
271F	3500 to 4200
271E	4200 to 4900
271A	4900 to 5700
271D	5700 to 6500

The final stage tuning inductors, which have a series condenser attached to them, cover the following approximate bands:

ANTENNA TYPE	CARRIER FREQUENCY IN KILOCYCLES	SERIES CAPACITY, MMF	WESTERN ELECTRIC TUNING COIL
Nose to tail 40′ fixed...	2000 to 3000	4000	7C
	3000 to 4000	4000	7B
	4000 to 5000	250	7B
	5000 to 6000	250	7A
	6000 to 6500	125	7A
Seventy ohm transmission line with tuning unit	2000 to 3500	250	7B
	3500 to 6500	250	7A

In the case of the seventy ohm line, a 1000 mmf condenser must be attached between the antenna post contact of relay S6 and ground.

Occasionally it will be found that the series condensers supplied will not give correct operation and a 62.5 mmf condenser may be used. The condensers are all of the PL6 Dubilier type except for the 1000 mmf condenser which is of the PL9 type. The low frequency band for 300 to 500 kilocycle operation requires a special output coil as well as a loading coil, as shown in the schematic of Fig. 88.

A special two scale test milliammeter on a standard telephone plug is used in adjusting the 13 type transmitter. An antenna current thermocouple is provided in the transmitter which should be short-circuited at the meter connection when not in use. A test bench setup shown in Fig. 89 can be used for initial adjustments.

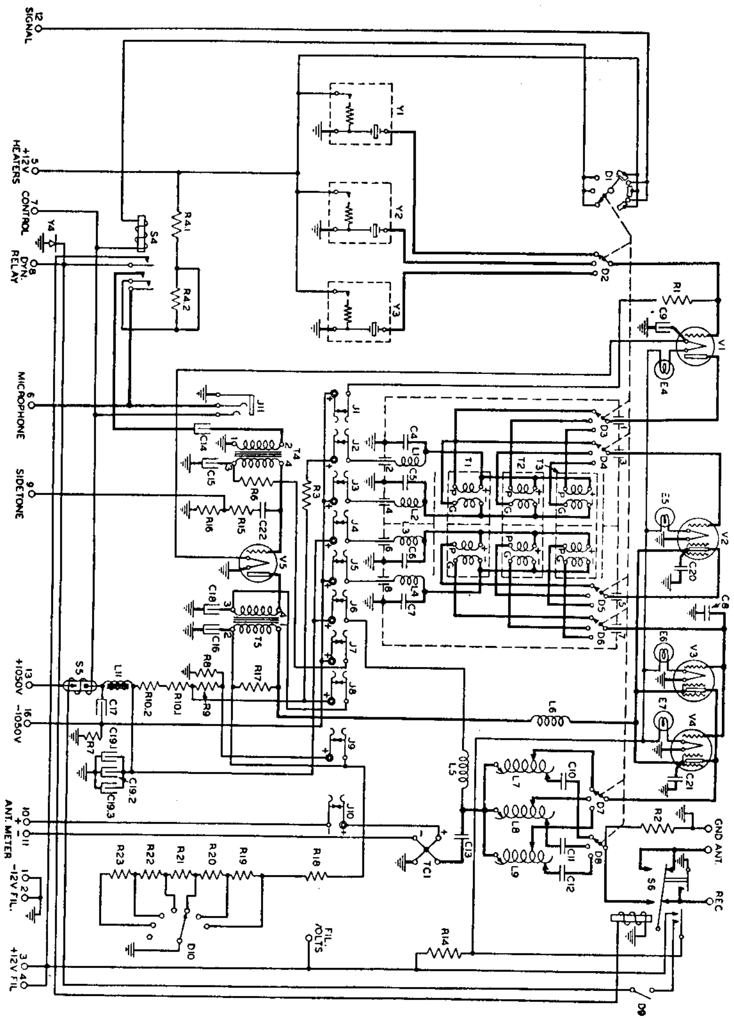

FIG. 86—WESTERN ELECTRIC 13C SCHEMATIC

Courtesy Western Electric Co.

The Number 1 channel is used for the lowest frequency while the Number 3 channel is used for the highest frequency, as there is a slight advantage in so doing.

The milliammeter is plugged into the "2nd A plate circuit" jack

for initial alignment. The cover must be on the transmitter while making adjustments in order to close the safety switch so that output

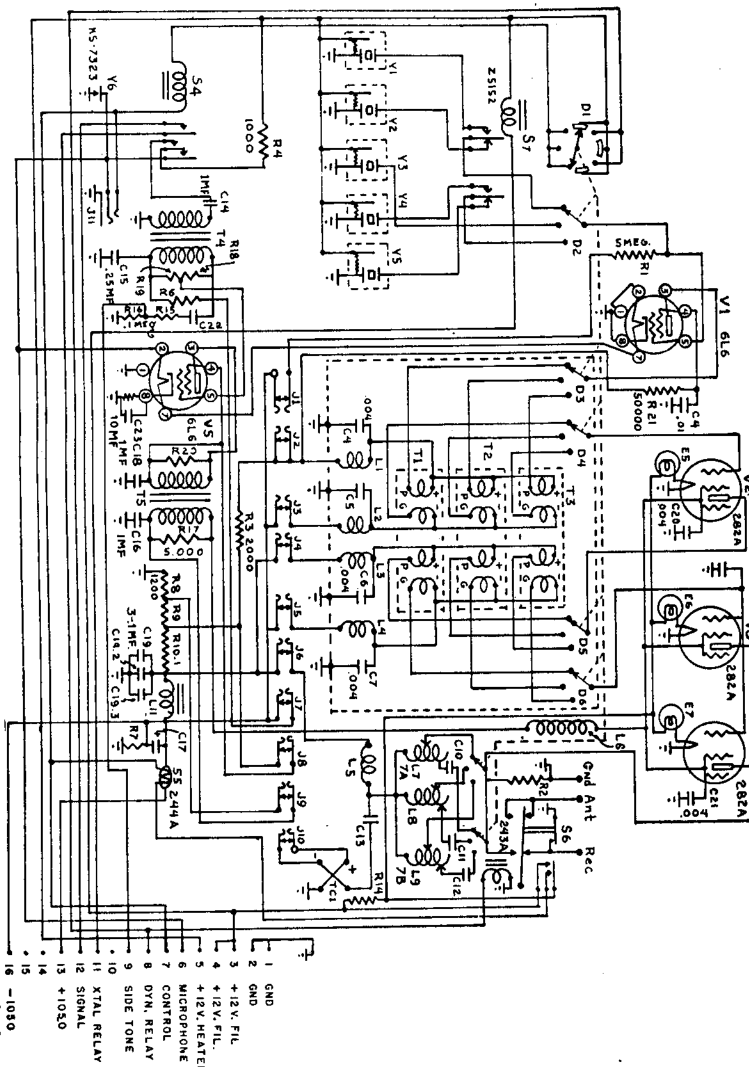

FIG. 87—MODIFIED 13C TRANSMITTER

Courtesy American Airlines

coils will not be affected. The antenna tuning trimmer reached, through the front panel, is adjusted on the highest frequency with the antenna attached after first turning the adjustment as far to the right, clockwise, as it will go with the antenna clip on the 7-type coil on the rear turn of the tuning coil and with the plate clip at about

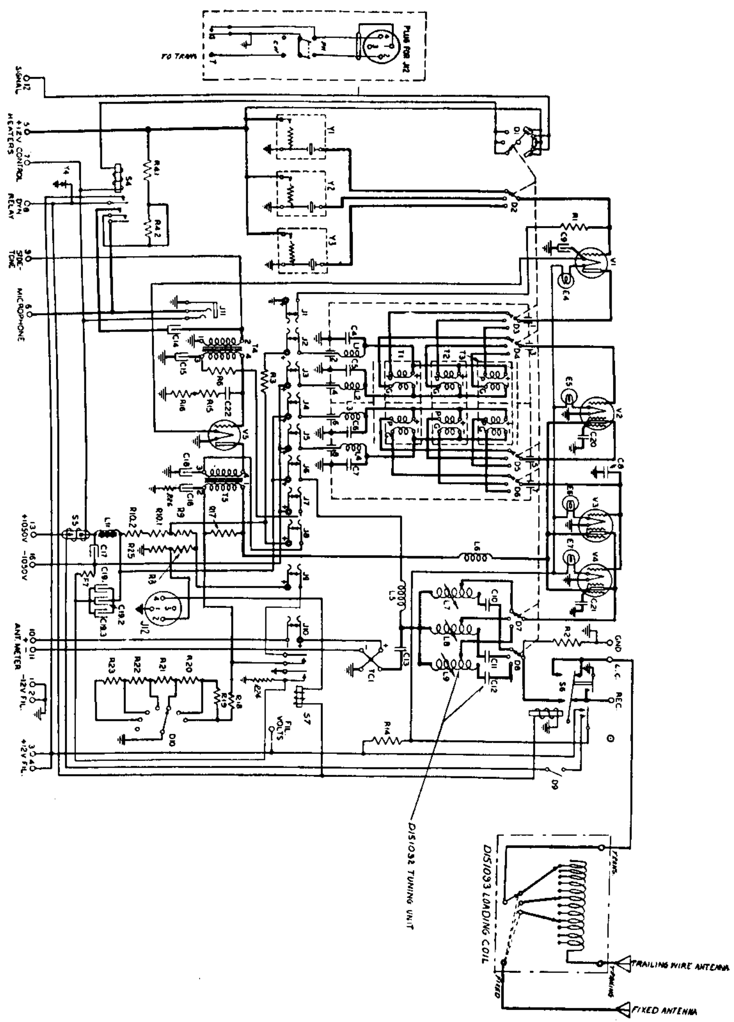

FIG. 88—WESTERN ELECTRIC 13CB TRANSMITTER

Courtesy Western Electric Co.

the center of the coil. The clips must not short-circuit turns but be on top of the wire and locked down with the catch. If there is no antenna current, as measured by a radio frequency ammeter in the

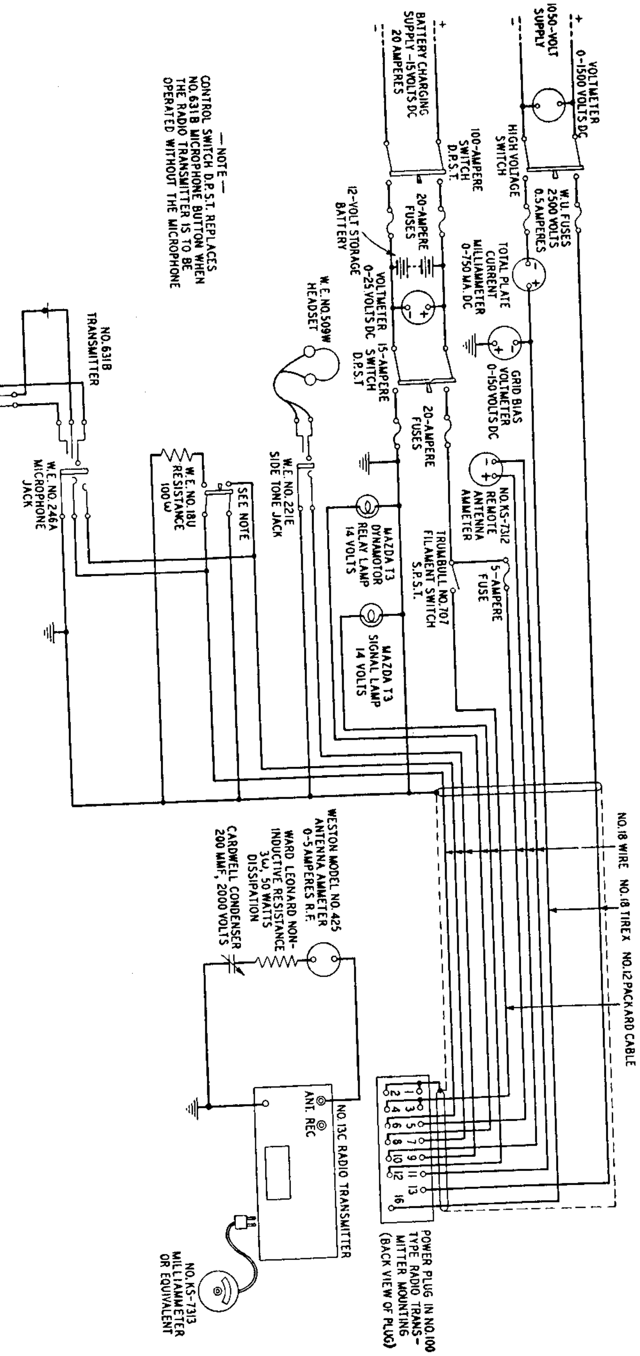

FIG. 89—TEST BENCH SETUP FOR 13B TRANSMITTER

Courtesy Western Electric Co.

Transmitters designed for use in airplanes must be light in weight, compact, and have the highest possible over-all power efficiency. This requires care in the design, and in some cases resort to special circuit arrangements to utilize effectively the full possibilities of the equipment.

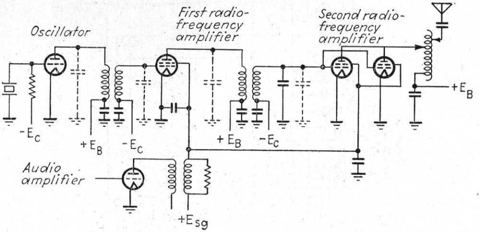

FIG. 293.—Schematic circuit diagram of Western Electric 50-watt transmitter intended for airplane use.

An example of such an arrangement is the Western Electric transmitter of Fig. 293. This consists of a crystal oscillator with the crystal ground to the frequency to be transmitted, followed by two stages of screen-grid radio-frequency amplification. Modulation is accomplished by simultaneously modulating the screen voltage of the tubes in both stages of radio amplification. The adjustment is such that the carrier wave is the high frequencies. Short-wave transmitters used for airplane, police, amateur, and other similar purposes are similar in a general way to short-wave broadcast transmitters but need not ordinarily meet the same high requirements with regard to stability of carrier frequency, audio-frequency range, and distortion. This permits the use of other modulation systems, such as the suppressor-grid modulated or control-

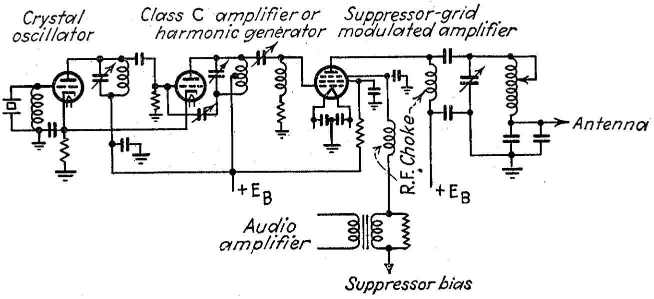

FIG. 292.—Typical amateur telephone transmitter employing suppressor-grid modulation.

grid modulated Class C amplifier in which the grid is driven positive. An example of a typical amateur transmitter employing suppressor-grid modulation is shown in Fig. 292.

Transmitters designed for use in airplanes must be light in weight, compact, and have the highest possible over-all power efficiency. This requires care in the design, and in some cases resort to special circuit arrangements to utilize effectively the full possibilities of the equipment.

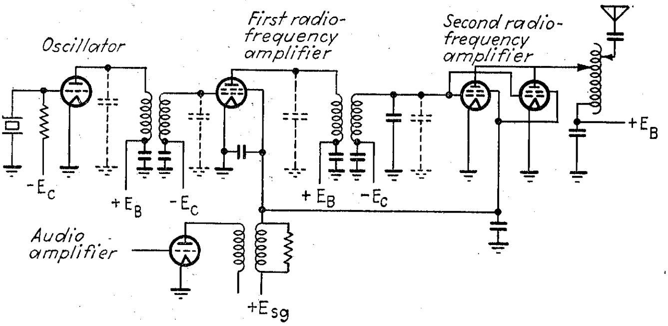

FIG. 293.—Schematic circuit diagram of Western Electric 50-watt transmitter intended for airplane use.

An example of such an arrangement is the Western Electric transmitter of Fig. 293. This consists of a crystal oscillator with the crystal ground to the frequency to be transmitted, followed by two stages of screen-grid radio-frequency amplification. Modulation is accomplished by simultaneously modulating the screen voltage of the tubes in both stages of radio amplification. The adjustment is such that the carrier wave is partially modulated in the first radio-frequency amplifier tube, and this partially modulated wave is then completely modulated in the second radio-frequency amplifier. With this particular transmitter it is possible to obtain complete modulation of a 50-watt carrier with only 1 watt of audio power and with a maximum dstortion of less than 10 per cent.