

SCHEMATIC MODEL DX-100

IMPROVED KEYING FOR THE DX-100

The original keying circuit of the DX-100 involved simultaneous keying of the VFO and buffer stages in the cathode circuit. The two remaining stages were biased to cutoff and remained idle until excited by the buffer. This method of keying is simple, fool-proof, and allows break-in operation. However as the VFO is started and stopped very suddenly there is a tendency toward chirps or frequency shift, particularly on the higher frequencies. Also, there may be key clicks as there is no provision for wave shaping.

The sudden starting of an oscillator produces a sharp wave front with a possibility of over-shoot and the following stages running class C further sharpen the wave front. This transient response results in harmonics which splatter over adjacent frequencies causing key clicks. See Figure 1.

From the above discussion you will see that there are two problems which must be solved before good keying is possible. One is to eliminate the chirp caused by a small, but instantaneous frequency shift of the VFO when power is applied suddenly. Two is to eliminate the extremely sharp wave front which produces harmonics causing clicks



Figure 1

A good solution to the chirp problem is to allow the VFO to run continuously and key a following stage. This might preclude the possibility of operating break-in on one's own frequency; however, the VFO in the DX-100 is well shielded in its own case and again shielded by the transmitter cabinet. Tests performed with a good receiver using coax antenna feed gave a reading of only S1 for the VFO signal. This would readily allow break-in on any frequency.



Figure 2

The solution to the click problem is to round off the corners of the transmitted wave and thus prevent the higher order harmonics. See Figure 2. This may be done by using a keying system that allows the introduction of a time constant in the circuit. The time constant slows the starting and stopping time and eliminates the sharp wave front and over-shoot.

Grid block keying is one method in which it is quite simple to introduce a time constant. In grid block keying a relatively high negative potential is applied to the grid of the keyed stage, cutting off the tube's conduction. When the key is depressed this negative voltage is shunted to ground and the tube allowed to operate.

OPERATION

In the following modification the key lead is removed from the phone-CW switch and connected to a separate tie point. Then pin 9 of the phone-CW switch is tied to pin 7. This results in the plate switch turning on the VFO and buffer stages whenever the high voltage is on, in the CW as well as the Phone position. However, the buffer stage is rendered inoperative by a negative bias and only the VFO operates.

As it would not be practical to tune up the low power stages with high voltage on the final, a push-button switch is installed which duplicates the effect of both the plate switch and the key without applying high voltage.

Approximately -60 volts is obtained from the bias supply and passed through two 27 K and one 100 K Ω resistors to the grid of the 12BY7 buffer cutting the tube off. See Figure 3. When the key is depressed the point between the two 27 K resistors is grounded. The first 27 K Ω resistor isolates the bias supply so that it is not shorted, the second 27 K resistor in conjunction

with the .15 μ fd capacitor provides the time constant for the "make" side of the wave. The .15 μ fd capacitor has to discharge through the 27 K resistor to ground by way of the key contacts. Thus, the negative voltage on the grid of the 12BY7 does not instantaneously fall to zero and a slope is introduced on the wave front. With the key down, the 12BY7 is self-biased through the 27 K and 100 K resistors. When the key is released the .15 μ fd capacitor has to charge through both 27 K resistors, and the tube grid voltage rises at a relatively slow rate to cut off. This produces a slope on the "break" and again eliminates the click.

INSTALLATION

The installation is extremely simple with the possible exception of boring the hole for the push-button switch. Using Figure 4, lay out the hole on the panel, then mark the spot with a center punch. Drill the hole first with a small drill to insure accuracy; it would be well to hold a plate or block behind the panel to protect the filter capacitors. Now drill the hole with progressively larger drills and if necessary use a reamer until a 3/8" hole is obtained.

Wire the push-button switch in the following manner before it is mounted: With a blade-type push-button switch such as the Switchcraft (1004), connect the two moving blades together and connect a wire approximately 7 inches long to this point. This wire should carry some means of identification such as a different color from others used. Connect two wires about the same length to the two stationary contacts of the switch. These wires need not be distinguished from each other. Mount the push-button switch on the panel and feed the three wires through the chassis hole between the filter capacitors. See Figure 5 for the following wiring. The identified wire is connected to terminal 1 of the key jack (ground); the other two wires are connected as shown. (green)

Mount a one-lug terminal strip near the key jack using the corner screw holding the filter capacitor. Mount a three-lug terminal strip behind the 12BY7 stage using the screw which holds the octagonal loading capacitor.

The key jack line choke is removed from terminal 9 of the phone-CW switch and connected to the one-lug terminal strip. Terminal 9 is then connected to terminal 7 with a jumper. The 100 K Ω resistor from pin 2 of the 12BY7 oscillator socket to ground is removed. The rest of the wiring is easily accomplished by following Figure 5.

ADJUSTMENT

After the modification has been completed, turn on the transmitter and readjust the clamp circuit. With plate power applied to the final and no excitation (VFO-xtal switch in an unused xtal position), set the clamp (screw driver adjustment) until the final plate current just returns to zero. Do not pass this setting.

Turn off the high voltage, set switch for VFO operation and while holding the push-button switch tune VFO and buffer for desired operating frequency. Now release push-button, turn on HV and tune final and loading for normal operation.

The push-button switch is used for frequency spotting or tune-up and the final tuned as before.

This modification is strictly optional on the part of the builder. It will work equally well for crystal or VFO operation and produces a far superior signal on both.

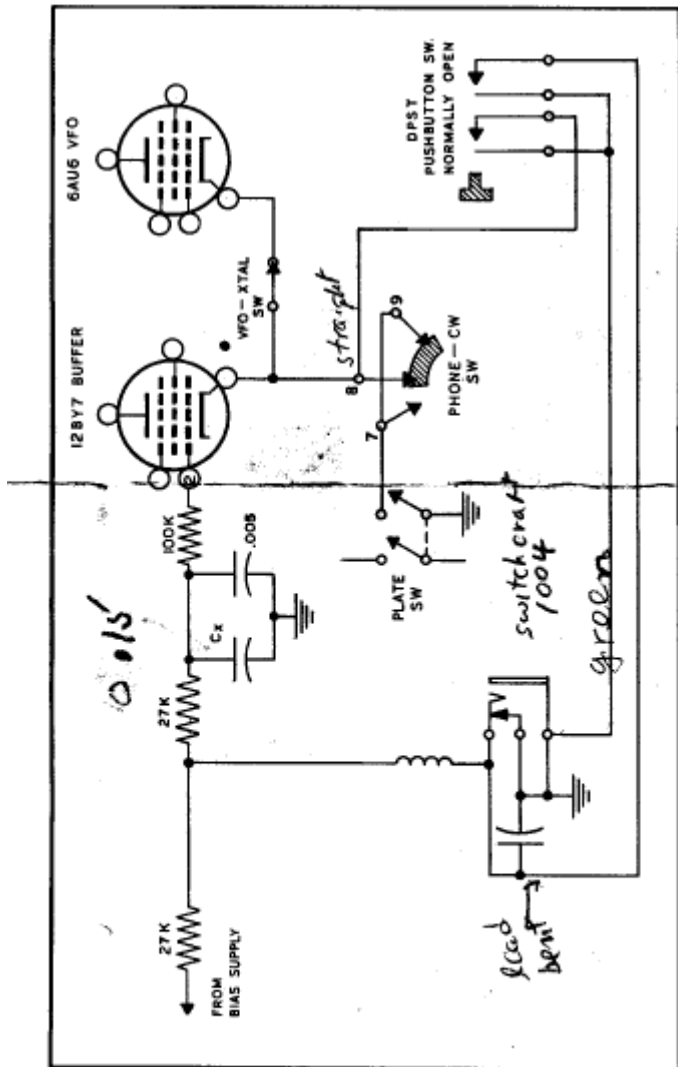


FIG. 3

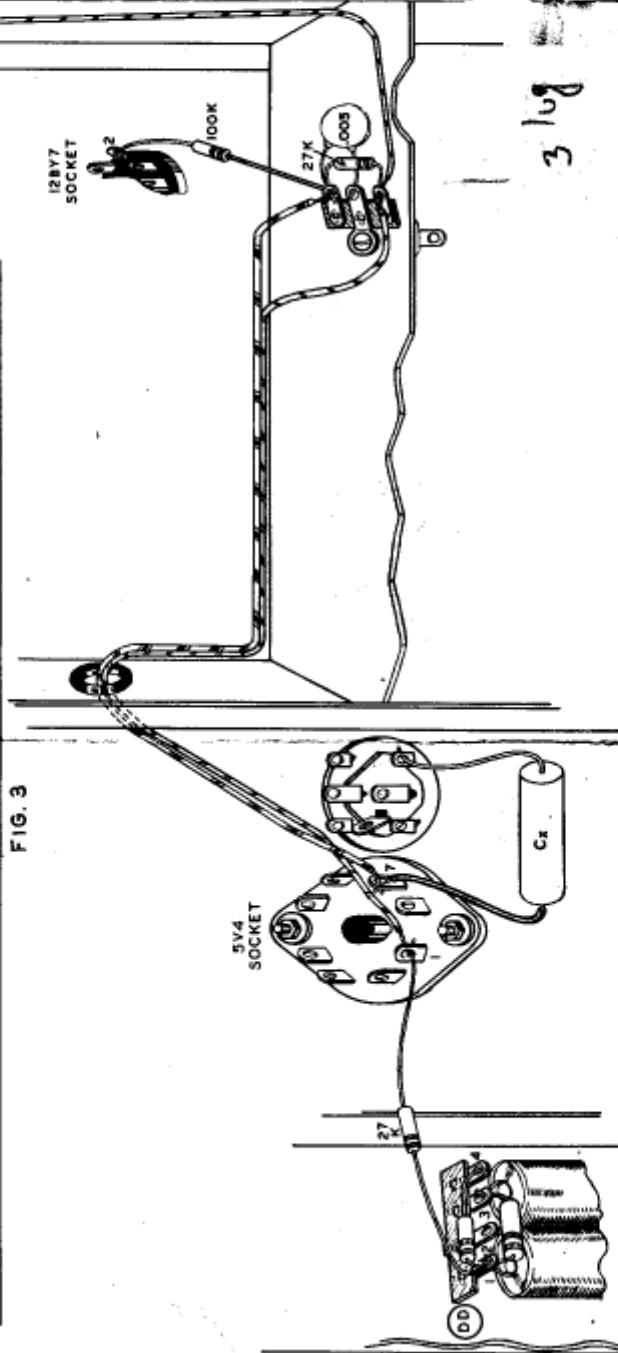
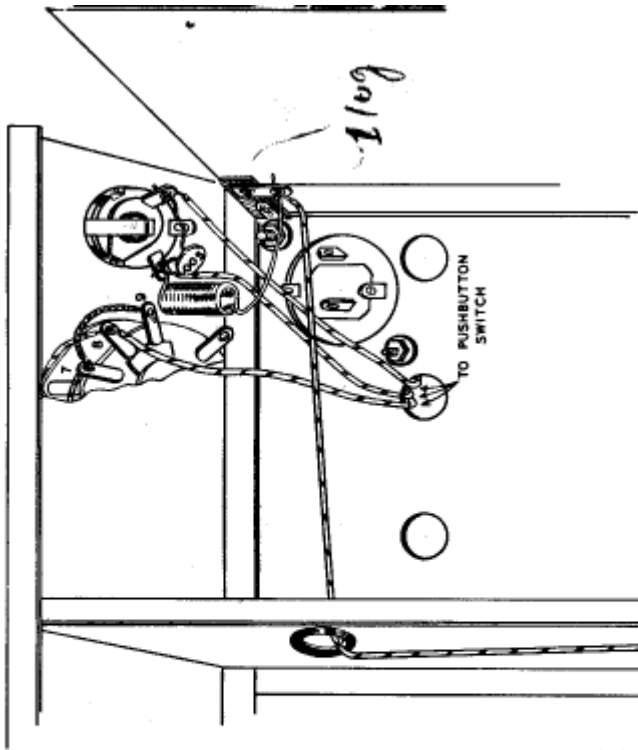


FIG. 5

- 1 ea switchcraft 1004
- 2 ea 27K resistors
- 1 ea 100K
- 1 ea .005
- 1 ea 0.015
- 1 ea 1 lug strip
- 1 ea 3 lug strip

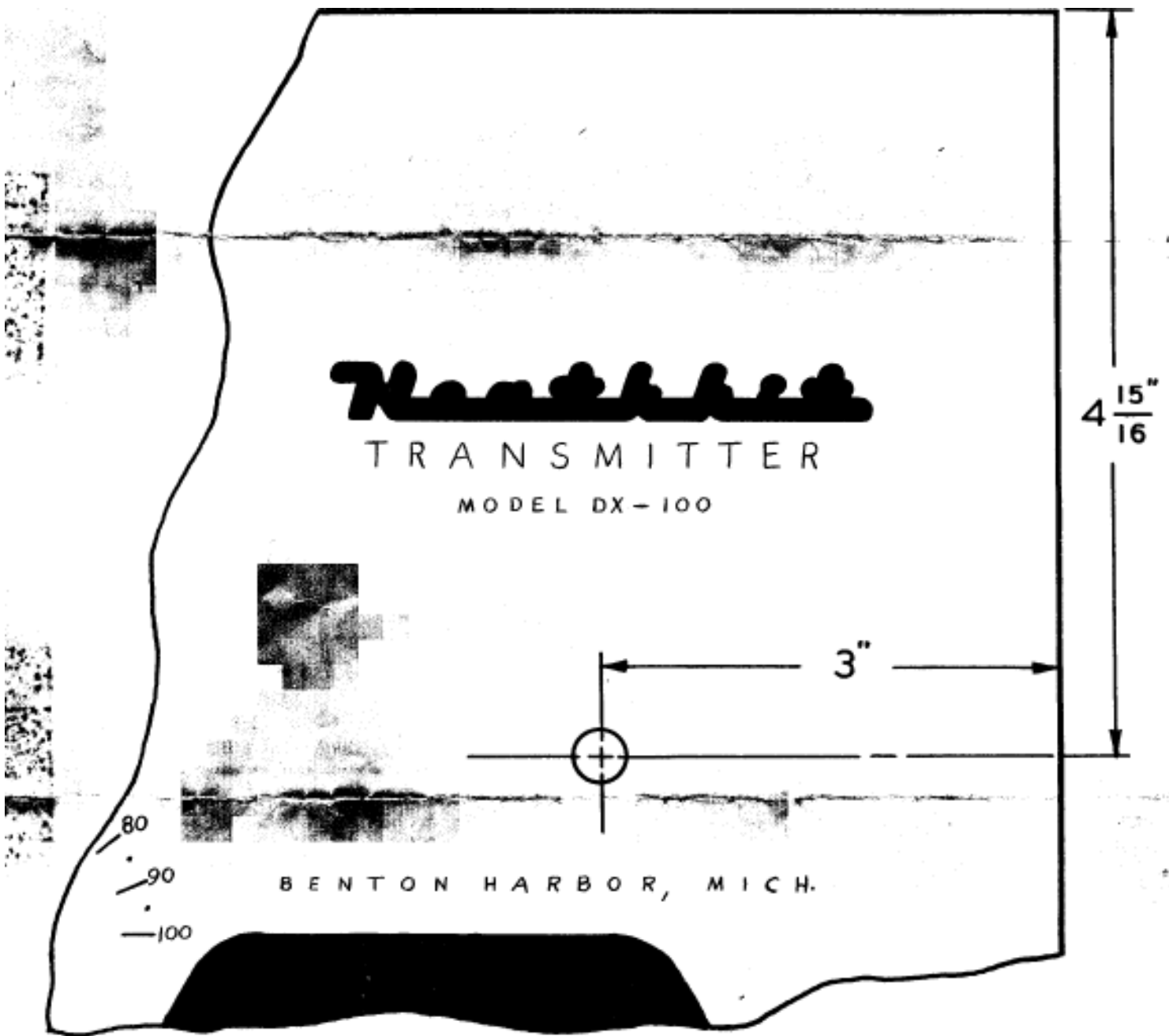
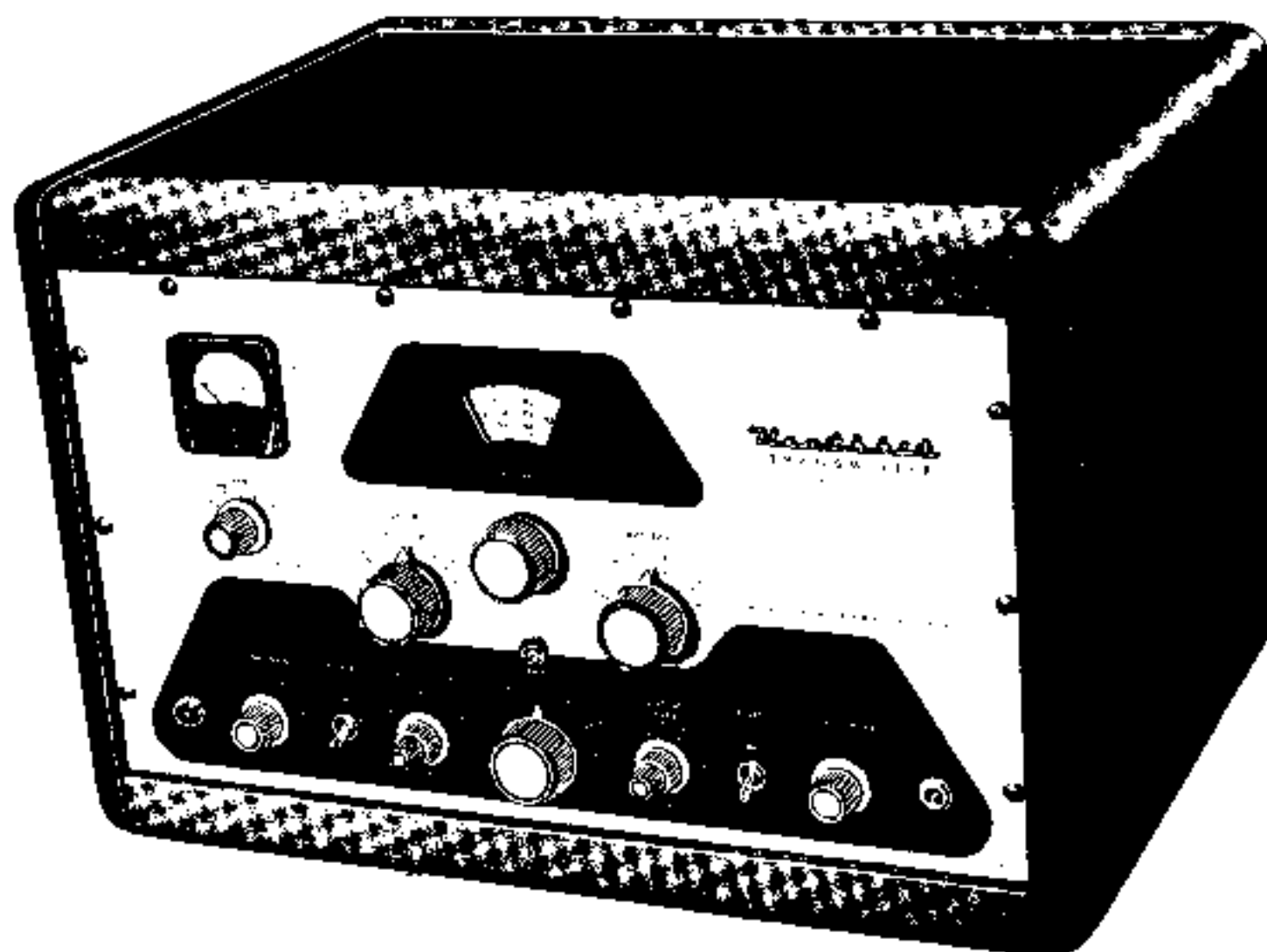


FIG. 4

HEATHKIT TRANSMITTER

MODEL DX-100



SPECIFICATIONS

RF Power Output.....	100-125 watts phone, 120-140 watts CW
Output Impedance.....	50-600 Ω (non-reactive)
Output Coupling.....	Pi network (coaxial)
Operation.....	Crystal-VFO, CW-Phone, Local-Remote
Band Coverage.....	160, 80, 40, 20, 15, 11, 10
Audio Output.....	85 watts at 300-3000 cycles
Tube Complement:	
Power Section.....	6AL5 bias rectifier 5V4 low voltage rectifier 2 - 5R4GY high voltage rectifier OA2 regulator
Audio Section.....	12AX7 speech amplifier 12BY7 audio driver 2 - 1625 modulator
RF Section.....	6AU6 VFO 12BY7 crystal oscillator-buffer 5763 driver 2 - 6146 parallel power amplifier 6AQ5 clamp
Power Requirements.....	115 volts AC, 50 to 60 cycles
Standby.....	150 watts
CW.....	400 watts (intermittent)
Phone.....	450-600 watts
Cabinet Size.....	20 7/8" wide x 13 3/4" high x 16" deep
Net Weight.....	100 lbs.
Shipping Weight.....	107 lbs.

INTRODUCTION

The Heathkit model DX-100 Transmitter represents the complete transmitting complement of the amateur operator station. The only external requirements are an antenna, ground and key or microphone. Panel controls allow VFO or crystal control, Phone or CW operation on all amateur bands up to 30 mc. The DX-100 includes three power supplies, low voltage, high voltage and fixed bias, four radio frequency stages and four audio stages.

The pi network output coupling tends to suppress harmonics and will match a wide range of antenna impedance. The original Heath VFO has been redesigned for use in the DX-100. The use of air trimmer capacitors, relocation of temperature compensating elements and tighter shielding, have improved the stability and operating characteristics. Panel controls include key and microphone connections, audio gain, crystal-VFO switch, drive control, bandswitch, fine and coarse loading controls, phone-CW switch, VFO tuning, driver tuning, final tuning, power and plate switches. A socket on the rear of the transmitter is so connected to allow remote control of the transmitter or to operate an antenna relay. It also makes 80 watts of audio at 500 Ω available for driving larger modulators or for public address work.

The following block diagram and circuit description will give the builder a better understanding of the transmitter. This knowledge is an invaluable aid to construction and as such, is well worth reading thoroughly.

IN A TRANSMITTER OF THIS SIZE, LETHAL VOLTAGES ARE PRESENT. CONSEQUENTLY GREAT CARE MUST BE EXERCISED WHEN ANY TESTS OR ADJUSTMENTS ARE MADE.

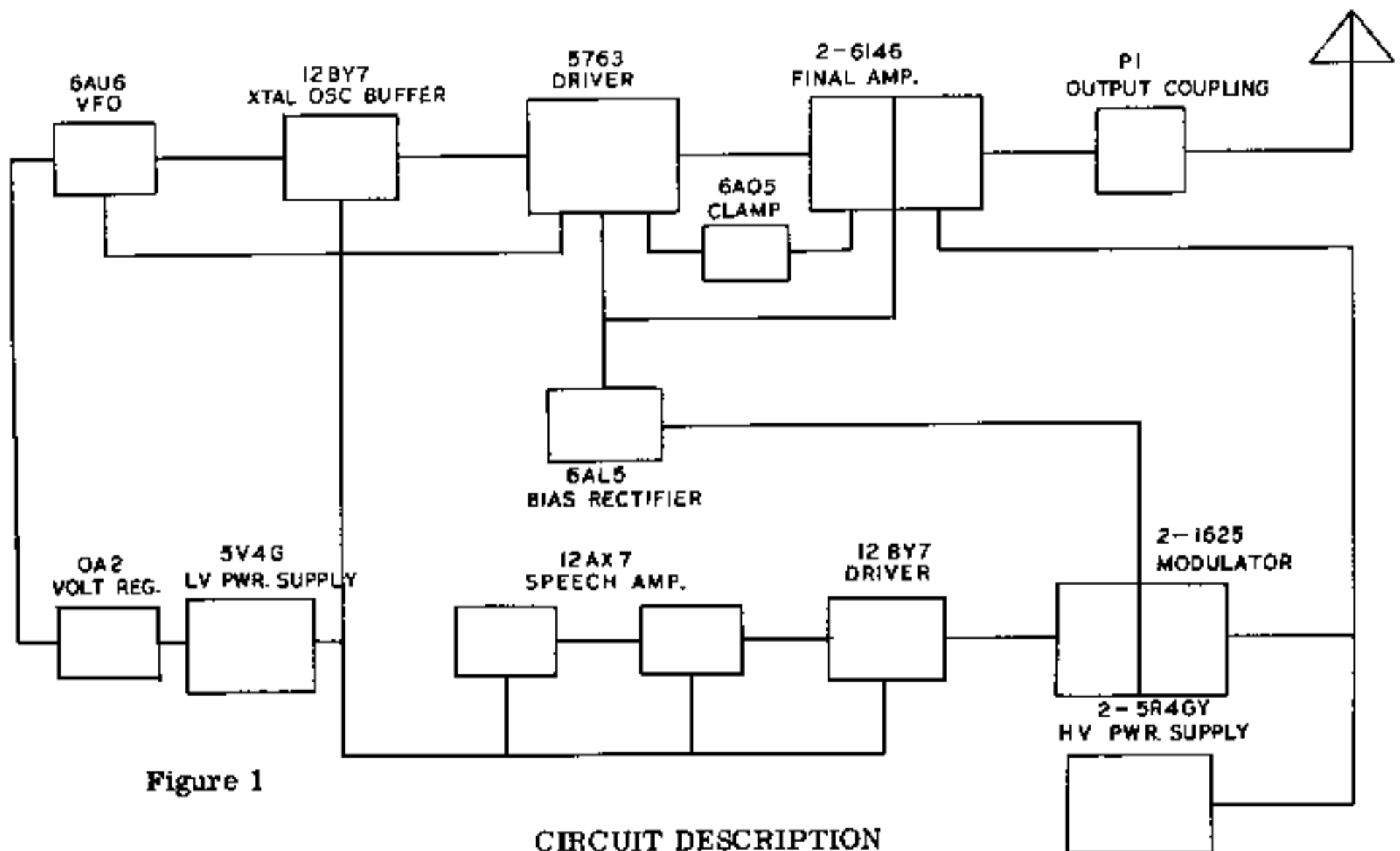


Figure 1

CIRCUIT DESCRIPTION VFO

The VFO circuit consists of a 6AU6 tube operating as a Clapp oscillator in the frequency ranges of 1750 to 2000 kc, 7000 to 7425 kc and 6740 to 6807.5 kc. To prevent undue heating effects, the tube is mounted on top and outside of the VFO enclosure. All the frequency determining components are mounted rigidly inside the shielded enclosure. A double bearing ceramic insulated tuning capacitor of the differential type is used as a frequency control. The differential capacitor having two stator assemblies of different capacity, permits a large bandspread at high frequencies as well as the lower frequencies. Ceramic insulated air trimmers prevent initial drift during calibration.

The coils are wound with Litz or double cellulose wire on heavy ceramic forms, doped with Q-max and baked. This combination achieves high Q, low drift and decreases the effect of humidity. Temperature compensating capacitors mounted in close proximity to the coils decrease slightly in capacity as the coil inductance increases with heating. The capacitors tend to raise the frequency and the inductances tend to lower the frequency. By properly proportioning these components, the effects of one cancel the other and the frequency remains constant. The VFO switch is mounted vertically inside the compartment and operated by an interrupted switching mechanism on the band switch. This correlates the VFO output frequency with the band in use.

The Clapp or series-tuned Colpitts oscillator circuit presents a very low impedance at resonance for the tube grid to look into. This minimizes the effect of shift in tube capacitance upon the output frequency. A large capacitive voltage divider necessary for operation of the Colpitts circuit, also lessens the effect of tube capacitance upon frequency. The 6AU6 tube is also operating as an electron-coupled oscillator, wherein the tube screen grid operates as the oscillator plate. The screen grid voltage is stabilized at 150 volts by an OA2 regulator in the power supply. With the screen grid operating as the oscillator plate, the actual tube plate is coupled to the oscillator only by the electron stream in the tube and further shielded from the oscillator by the grounded suppressor grid. This effectively isolates the oscillator circuit from the following stages and lessens the effect of loading on the VFO frequency. The output of the VFO is broadbanded and fed to one position of the XTAL-VFO switch. This switch also opens the cathode circuit of the 6AU6 when in any crystal position, thus disabling the VFO when using crystal control.

CRYSTAL OSCILLATOR-BUFFER

A 12BY7 tube is used as a modified Pierce crystal oscillator. This circuit is basically a grounded cathode Colpitts oscillator with the grid-cathode and screen-cathode capacities serving as the capacity voltage divider. In the first four positions of the XTAL-VFO switch, crystals are connected between the grid and screen of the 12BY7. In the fifth position, the VFO output is connected between grid and ground of the 12BY7 and the VFO cathode is connected to the cathode of the 12BY7. The cathodes of both tubes are then directed to either the key jack or one-half of the plate power switch by means of the CW-PHONE switch. The plate circuit of the 12BY7 is untuned when operating 160 or 80 meters, slug tuned to 40 meters for operation at 40, 20 or 15, meters and slug tuned to 20 meters when operating in the 10-11 meter band. An untuned RF choke and the two slug-tuned coils are in series from B+ to the tube plate. One section of the band switch shorts out the coils not being used for a given band. The output of the 12BY7 is capacity coupled to the 5763 driver stage.

DRIVER STAGE

A 5763 tube operating with a combination of fixed and automatic bias, is used to drive the final amplifier. As the stage has plate voltage supplied and the cathode circuit closed, sufficient bias is necessary to keep it from drawing plate current during key up or standby conditions. The additional automatic bias establishes the operating bias during "key down" condition. A meter shunt resistor is permanently connected in the cathode circuit and the meter switched across it when reading driver current. The resistance of the shunt is such as to cause the meter to read 50 milliamperes full scale. Potentiometer control of the driver screen voltage allows control of the grid drive to the final amplifier. The plate circuit of the 5763 is shunt fed through an RF choke. Pi network interstage coupling is used between the driver and a final amplifier with the input capacitor of the pi section variable and the output capacitor fixed. The pi section inductance is tapped and the proper tap for each band selected by a section of the band switch. The use of pi network interstage coupling helps reduce the harmonic output of the transmitter. The fixed output capacitor of the pi interstage coupling appears from grid to ground of the final amplifier and shorts out the higher frequency harmonics.

FINAL AMPLIFIER

Two 6146 tubes operating at approximately 740 volts are used as the power amplifier. Here also, a combination of fixed and automatic bias is used to establish the operating and standby condition. In addition to the fixed bias, the screens of the tubes are clamped by a 6AQ5. The action of the clamp tube is as follows:

The screen voltage to the 6146's is obtained through a dropping resistor from the plate supply and the 6AQ5 tube plate is connected at the 6146 screen. The 6AQ5 cathode is grounded and its grid is common to the grid circuit of the 6146 stage. As long as grid excitation is obtained from the preceding stage, the bias developed keeps the clamp tube cut off and it does not draw current. If excitation is lost, the 6AQ5 grid goes to zero and the tube draws heavy current, dropping the voltage to the 6146 screen to a very low value, thus further protecting the 6146 stage. The fixed bias applied to the grids of the 6146 stage would normally keep the 6AQ5 cut off also, regardless of loss of excitation. Consequently, a sufficient positive voltage is applied to the 6AQ5 grid to just balance the fixed bias but not the operating bias. This allows the clamp tube to be cut off by the operating bias only.

The tank circuit of the 6146 stage is pi coupled to the antenna, using a 350 $\mu\mu\text{f}$ variable capacitor on the input side, a tapped inductance operating from the band switch and a variable capacitor with additional fixed capacitors on the output. A unique switching system with four fixed capacitors of 200, 400, 600 and 800 $\mu\mu\text{f}$ form combinations of these capacities allowing the coarse loading control to switch from 0 to 2000 $\mu\mu\text{f}$ in 200 $\mu\mu\text{f}$ steps. A 250 $\mu\mu\text{f}$ variable capacitor as a fine loading control, fills the space between steps. This permits smooth control of the loading capacitor from 15 $\mu\mu\text{f}$ to 2250 $\mu\mu\text{f}$.

When modulating tetrode tubes, it is necessary to modulate the screen as well as the plate. This is accomplished by supplying the screen voltage through a dropping resistor from the plate voltage. The 6146 tubes are sub-mounted on a separate plate. This serves two purposes. The plate acts as a shield to isolate the 6146 grids from the output circuit and the sub-mounting forms a chimney effect causing air to flow up past the tubes for cooling.

AUDIO SECTION

Two triode stages of resistance coupled speech amplification are combined in a 12AX7 tube giving sufficient gain for a low level crystal or dynamic microphone. In amateur communications, it is desirable to sacrifice fidelity in favor of narrow bandwidth and confine the power transmitted to voice frequencies, a range of about 250 to 3000 cycles. To limit the low frequency response of the speech amplifier, the coupling condensers are small, 500 $\mu\mu\text{f}$. This presents a high reactance to the lower frequencies. The higher frequencies over 3000 cycles per second, are eliminated in the modulator stage.

The 12BY7 driver tube is triode connected to present a low impedance to the modulator grids. In class AB2 audio, the modulator grids draw current on positive peaks, consequently the driver stage must deliver power to the grids. By using a low impedance power source, less variation will result between times of load or no load, as the driver swings from positive to negative. The 12BY7 driver feeds the modulator grids through a 2 to 1 step-down transformer, thus further lowering the grid impedance. Two 1625 tubes operating class AB2 constitute the modulator stage. They are capable of approximately 120 watts output but are normally operated at an 80 to 90 watt level. Series resistors in the grid circuit prevent the grids from swinging too far positive and thus limit the output below the highest obtainable.

The primary of the modulation transformer has a higher impedance than the 1625 tubes would normally work into. This introduces some high-level speech clipping, which in turn increases the average modulation percentage. To eliminate any splatter, as a result of speech clipping, the modulation transformer has been "built out" as a low pass filter. This also attenuates the high frequencies above the speech range. When the transmitter is operated on CW, the CW-phone switch removes the screen voltage from the modulator tubes and shorts the secondary of the modulation transformer.

POWER SUPPLIES

The low voltage power transformer contains all of the filament windings, including the filament for the high voltage rectifiers. It also has a tapped secondary to supply the bias rectifier. A 12 volt center tap winding supplies all of the audio and RF stage filaments. The center tap is grounded and the 6 volt tubes operated from one or the other side to ground, so as to place a balanced load on both halves of the winding.

The 12 volt tubes are operated across both halves of the winding. The low voltage supply with a 5V4G rectifier and condenser input filter, delivers 360 volts at 150 mils to the low power audio and RF stages. The taps on the secondary deliver 75 volts to the 6AL5 bias rectifier, also with a condenser input filter. A resistance network on the bias supply applies the correct bias to the final amplifier, modulator and driver stages.

HIGH VOLTAGE POWER SUPPLY

The high voltage supply consists of the plate transformer, parallel 5R4GY rectifiers, choke input filter and two 125 μ fd electrolytic capacitors in series. A center tapped bleeder balances the series capacitors and also furnishes the modulator screen voltage.

Ordinarily well designed power supplies, using conventional values of paper or oil capacitors, have been found to make violent voltage excursions as loads are suddenly applied or removed. This is known as the dynamic regulation characteristic. To eliminate these voltage excursions, larger capacitors than are practical in the paper or oil type are necessary. This makes the use of electrolytic types mandatory. The DX-100 uses two 125 μ fd 450 volt electrolytic capacitors in series, resulting in a filter capacity of 62.5 μ fd at 900 volts. This is sufficient capacity to assure good dynamic regulation under keying conditions and a fair safety factor on voltage breakdown. Both sides of the AC line are fused in a special line plug and all circuits entering or leaving the transmitter chassis have LC harmonic filters.

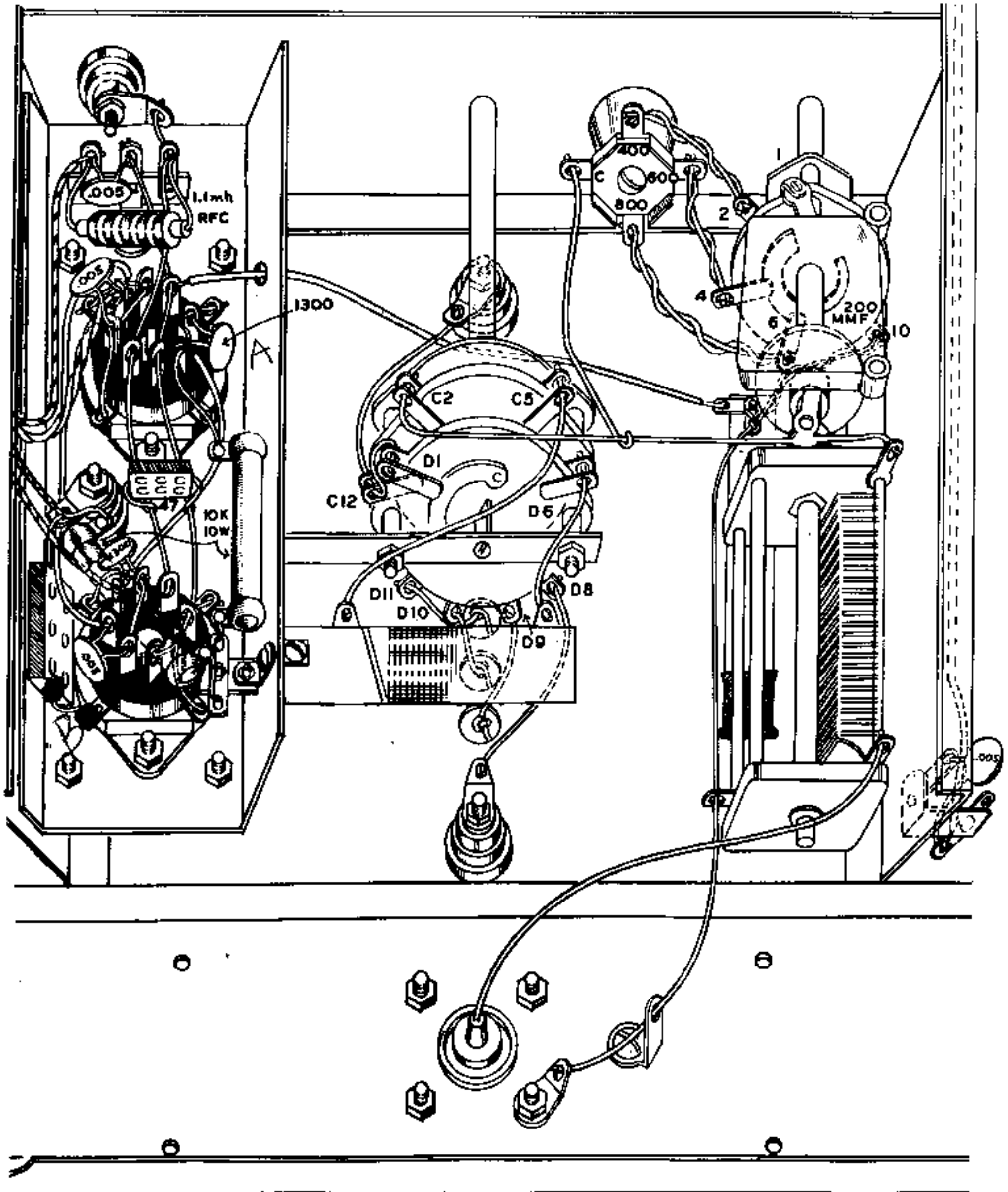
NOTES ON ASSEMBLY AND WIRING

In the design of the Heathkit DX-100, no effort was spared to obtain the highest quality components and assemble them in the best possible arrangement. As this transmitter represents a substantial investment, the kit builder should exercise a great deal of care during assembly and wiring. Only by putting the best possible workmanship into the kit, can the best results be obtained from it. There is also a great deal of personal satisfaction in a neat, professional looking transmitter, resulting from careful assembly and wiring. A common factor of radio frequency instruments is the critical placement of leads and components. The use of extensive shielding in the DX-100 has eliminated a great deal of this. However, the lead dress shown in the pictorials should be followed carefully.

Due to the complexity of the DX-100, the construction has been sub-divided into several stages. This unit method of construction reduces one large difficult project to several small easy ones. It also postpones the bulkiness and weight to be encountered in a large transmitter until it is nearly completed. This manual is supplied to assist you in every way to complete the DX-100 with the least possible chance for error. We suggest that you take a few minutes now and read the entire manual through before any work is started. This will enable you to proceed with the work much faster when construction is begun. The large fold-in pictorials are handy to attach to the wall above your work space. Their use will greatly simplify the construction of the kit. These diagrams are repeated in smaller form within the manual. We suggest that you retain the manual in your files for future reference, both in the use of the DX-100 and for its maintenance. During the initial testing of the transmitter, it will not be in its cabinet. **REMEMBER VOLTAGES DANGEROUS TO LIFE ARE PRESENT AT PRACTICALLY ALL POINTS ON THE CHASSIS.**

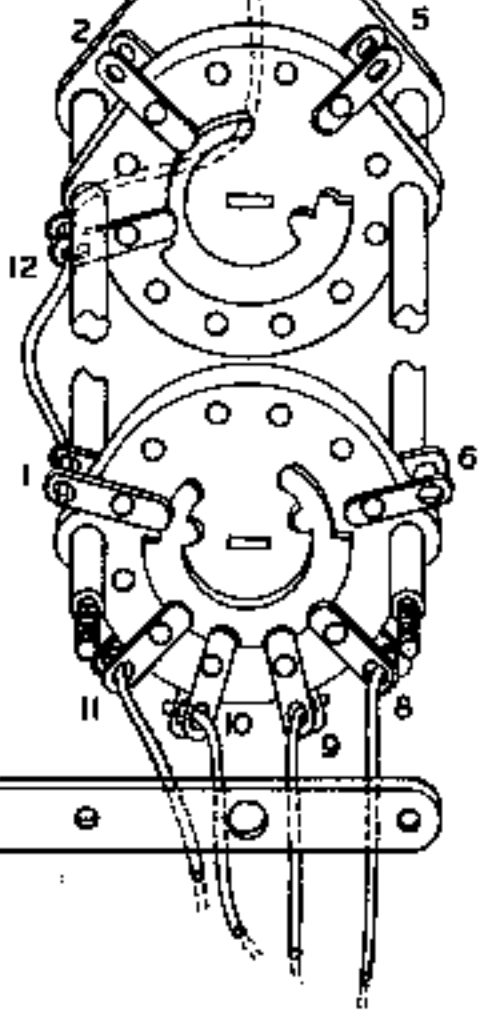
UNPACK THE KIT CAREFULLY AND CHECK EACH PART AGAINST THE PARTS LIST. In so doing, you will become acquainted with each part. Refer to the charts and other information shown on the inside covers of the manual and on Page 63 to help you identify any parts about which there may be a question. If some shortage is found in checking the parts, please notify us promptly and return the inspection slip with your letter to us. Hardware items are counted by weight and if a few are missing, please obtain them locally if at all possible.

Read the note on soldering on the inside of the back cover. Crimp all leads tightly to the terminal before soldering. Be sure both the lead and terminal are free of wax, corrosion or other foreign substances. Use only the best rosin core solder, preferably a type containing the new activated fluxes such as Kester "Resin-Five," Ersin "Multicore" or similar types.



PICTORIAL 8

FORMED
LEAD



C

D

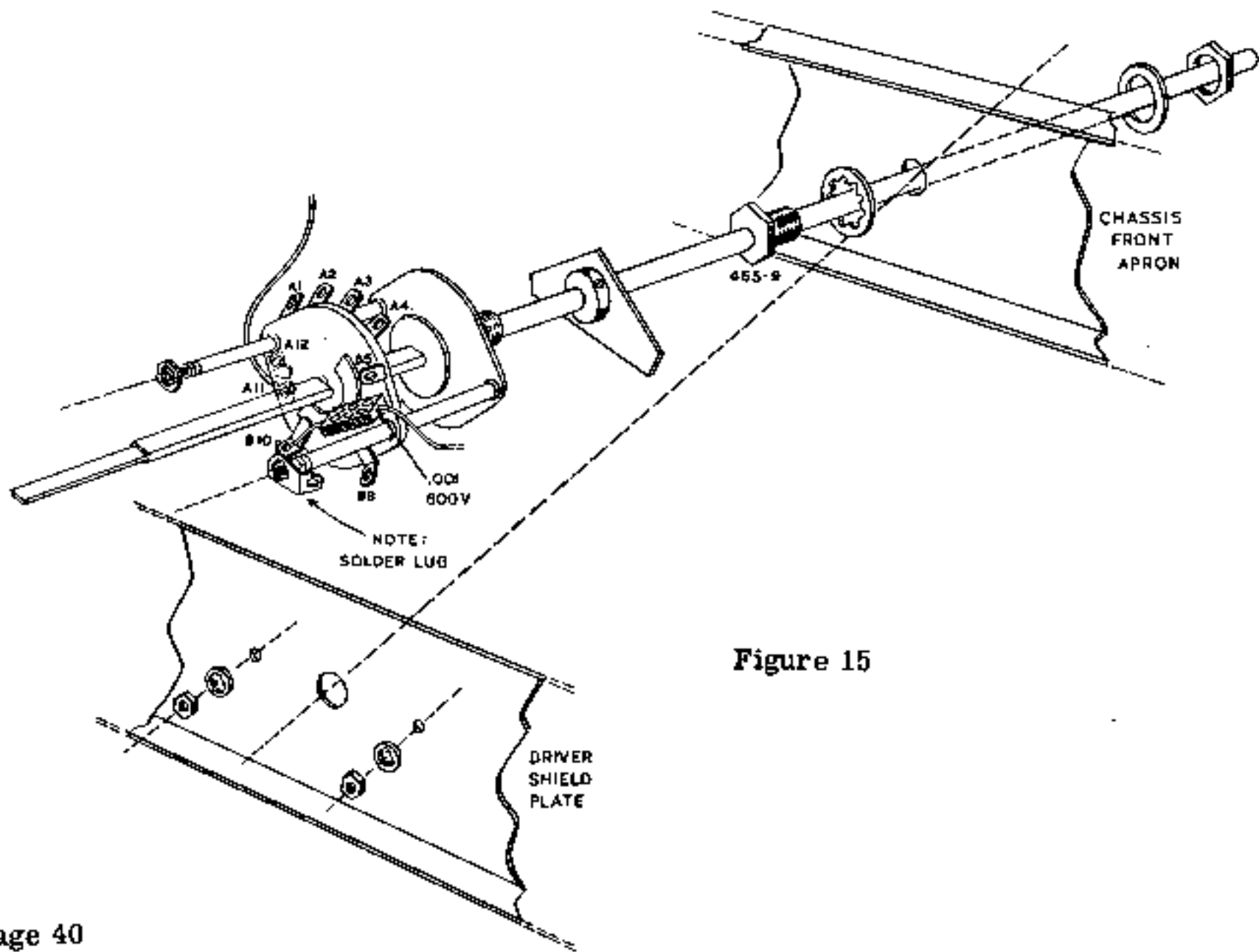


Figure 15

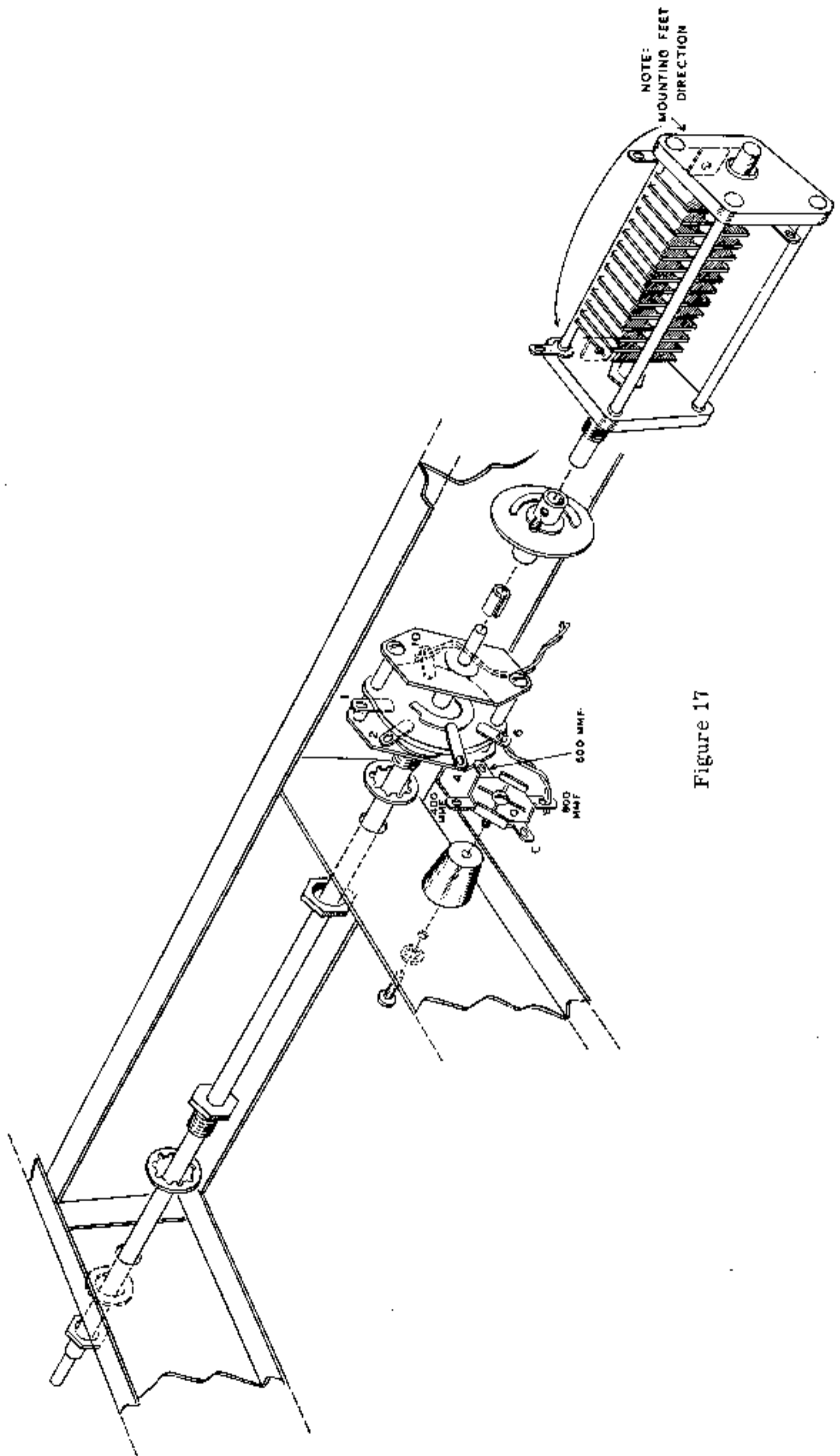


Figure 17

TUNING INSTRUCTIONS

NOTE: See Figure 19 for a description and the location of all operational controls on the transmitter before beginning the tuning procedure. A knowledge of each control function will assist in accomplishing the tuning without difficulty.

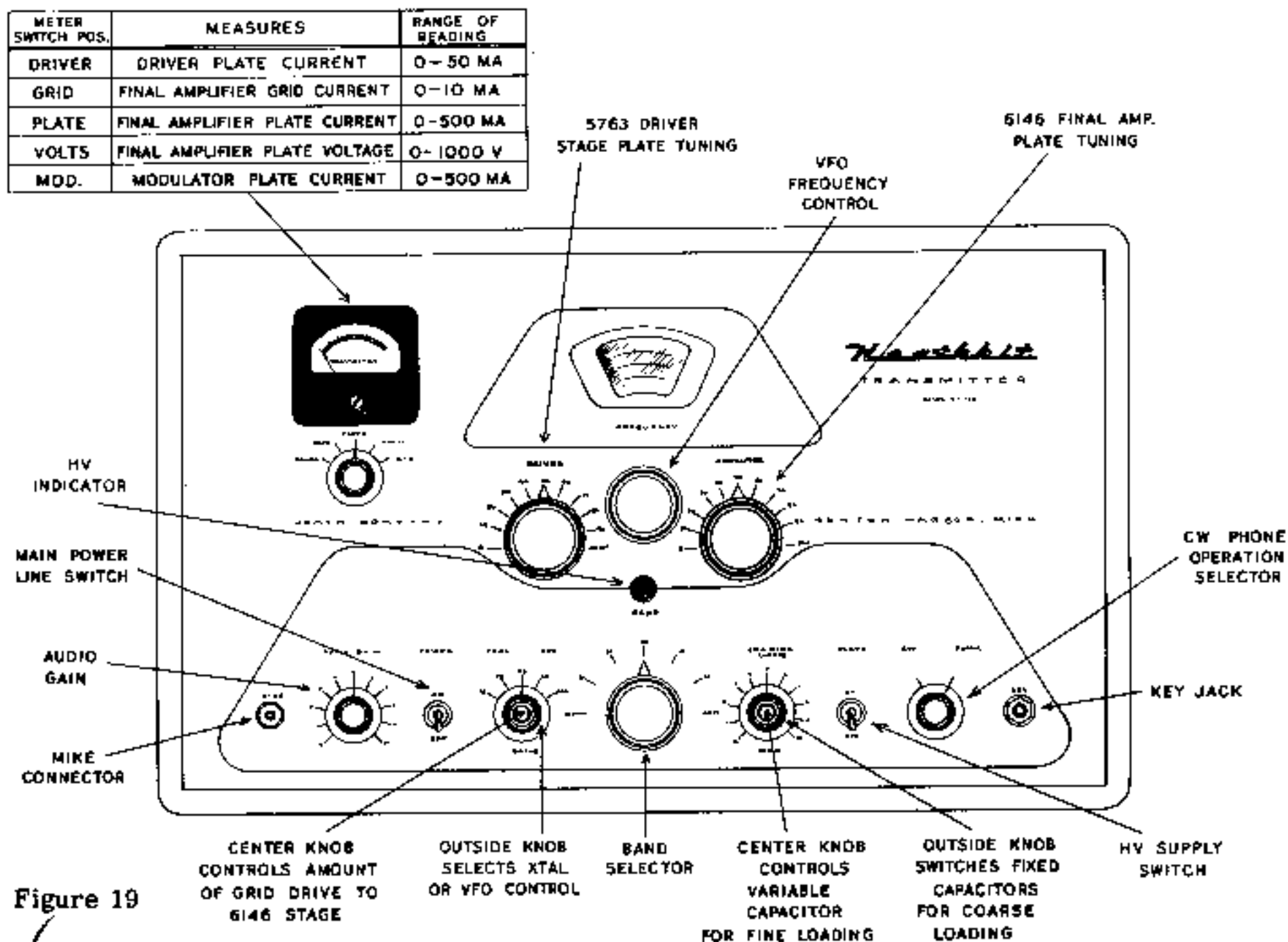


Figure 19

- (✓) Insert all tubes in the proper sockets. Refer back to Pictorial 9 on Page 46 for identification of sockets. Install VFO pilot lamp in its socket.
- () Plug a crystal into the X1 crystal socket (the one closest to the front panel). Select a crystal that will fall within one of the amateur bands, preferably a frequency lower than 40 meters.
- () Connect a 100 watt light bulb to the coaxial connector on the back chassis apron to act as a dummy antenna. This may best be done with the bulb inserted in a porcelain socket. One lead from the bulb should connect to the center portion of the connector and the other should connect to the chassis. A banana plug and alligator clip are convenient for the connections or a short length of coaxial cable may be fitted with a connector at one end and soldered to the light bulb at the other.
- () Before applying power, set the control knobs and switches as follows:

AUDIO GAIN - counterclockwise.
POWER - off.
XTAL-VFO - X1.
DRIVE - counterclockwise.
BAND - set bandswitch to proper band for crystal frequency used.
LOADING - set coarse control fully counterclockwise and fine control so indicator points to position 2.

PLATE - off.
CW-PHONE - CW position.
METER - grid.
DRIVER - 50.
FREQUENCY - no special setting at this time.
AMPLIFIER - 50.
CLAMP - fully counterclockwise. (See NOTE.)

NOTE: This is the screwdriver adjustment on the top side of the chassis immediately behind the panel and adjacent to the VFO enclosure and the 6AQ5 tube. (See Pictorial 9.)

CAUTION: BEFORE APPLYING POWER TO THE TRANSMITTER, IT SHOULD BE NOTED THAT LETHAL VOLTAGES ARE PRESENT BOTH ABOVE AND BELOW THE CHASSIS. CARE SHOULD BE EXERCISED NOT TO TOUCH ANY HIGH VOLTAGE POINTS WITH YOUR HANDS. WELL INSULATED TOOLS SHOULD BE USED FOR BEHIND THE PANEL ADJUSTMENTS.

NOTE: At this point, the scale on the meter should be studied carefully to determine just how the meter reads for the various positions of the meter switch. First note that the meter has two scales; one from 0 to 50 and one from 0 to 10. The scales should be interpreted as follows:

METER SWITCH POSITION	MEASURES	RANGE OF READING
Driver	Driver plate current	0-50 ma
Grid	Final amplifier grid current	0-10 ma
Plate	Final amplifier plate current	0-500 ma
Volts	Final amplifier plate voltage	0-1000 volts
MOD.	Modulator plate current	0-500 ma

- () Insert fuses and plug transmitter into a 115 volt AC outlet.
- () Turn the power switch to ON and check to be sure that all the tubes light up. Switch the power off and recheck your wiring if any overheating is observed.
- () If nothing unusual is observed under these conditions, advance the driver control (small red knob centered in XTAL-VFO switch) slightly. Then adjust the DRIVER tuning control for a peak reading. CAUTION: Do not hold the reading above 6 ma for more than an instant. See if at least 6 ma is available through adjustment of the DRIVE control with the DRIVER tuning peaked. Leave grid drive set to 5 ma. Note position of grid DRIVE control knob with 5 ma on the meter so you can return to this setting later. This indicates proper functioning of crystal oscillator and driver stages.
- () Move the XTAL-VFO switch to VFO and peak the VFO FREQUENCY knob until a maximum reading is obtained on the meter. Increase or decrease the grid DRIVE to maintain the 5 ma reading. The VFO frequency dial indication is not significant at this time. VFO calibration will be accomplished later. If at least 6 ma of drive can be obtained, it indicates that the VFO is working also.
- () To test the final amplifier, return the grid DRIVE control to full counterclockwise position, reducing the drive to zero. Move the meter switch to PLATE and the PLATE switch to ON. Turn this switch off immediately in case of any arc, apparent overload or an excessive meter reading (over 300 milliamperes). Normally the meter should not read or should read only slightly up-scale.
- () Move the XTAL-VFO switch to one of the unused crystal positions and adjust the *clamp adj.* control behind the panel until the meter reading just returns to zero. Then return the XTAL-VFO switch to the VFO position.
- () With the meter still in the PLATE position, adjust the grid DRIVE control with one hand and AMPLIFIER tuning with the other. Advance the drive slowly while simultaneously tuning the amplifier for minimum on the meter, until the grid DRIVE control knob is positioned as it was previously for 5 ma drive level. CAUTION: Do not let the amplifier plate current exceed 300 ma under any circumstances. With the plate current dipped to minimum by the amplifier tuning, return the meter switch to GRID and set the grid drive to 5 ma. Switch back to PLATE and dip the AMPLIFIER tuning again. The final plate current should now read in the lower portion of the meter scale.

NOTE: On some bands it is possible to obtain two dips with the **AMPLIFIER** tuning. To eliminate the possibility of doubling in the amplifier, always select the dip at the highest reading on the **AMPLIFIER** tuning. (Capacitor plates near full mesh.)

- () Rotate the **COARSE LOADING** control a step at a time, dipping the amplifier after each step. The meter reading should increase with each step of load, as should the light bulb brilliance. When final reading is approximately 200 milliamperes, adjust the **FINE LOADING** control (still maintaining a dip with **AMPLIFIER** tuning control) for normal operating load of about 250 ma on the meter. Recheck grid current to be sure it still reads 5 ma. If reading has dropped, increase the grid **DRIVE** control to restore 5 ma reading. Now return the meter switch to the **PLATE** position.
- () Phone operation may be tested as follows: With all other controls set the same, turn the **PLATE** switch to **OFF** and move the **CW-PHONE** switch to **PHONE**. Connect a high impedance microphone to the **MIKE** input connector. Move the **PLATE** switch **ON**. The plate current reading should be slightly lower than for **CW** (240 ma). Move the meter switch to the **MOD.** position and speak into the microphone while slowly advancing the audio **GAIN** control. The control should be set so that the audio peaks hit about 125 ma. Without modulation, the reading will be around 50 ma. The light bulb used for a dummy load should peak upward in brilliance with peaks in audio modulation.

CALIBRATION

If the kit constructor has access to an **LM** or **BC** frequency standard, they are excellent for calibration. The other alternative is to accumulate as many crystals in the bands concerned as possible. The crystals preferably should be near the edge of the bands. The crystals may be inserted in the crystal sockets of the transmitter and compared to the **VFO** frequency by means of a nearby receiver having a **BFO**. If the frequency meter is used the frequency meter and **VFO** signals can beat against each other in the receiver. Before beginning calibration, allow **VFO**, frequency meter and receiver to warm up for one-half hour or more. If a **BC-221** frequency meter or equivalent is used (do not use ordinary radio service generators) it should be set to 1750 kc. If the crystal oscillator is used, have frequency as near as possible to 1750 or 3500 kc.

During the alignment procedure, the **DRIVE** control should be fully counterclockwise, the **CW-PHONE** switch should be on **CW** and the **PLATE** switch should be **OFF**. **NOTE:** If a frequency meter is used for calibration, the frequency meter signal and the **VFO** signal should be zero beat against each other in a receiver with the **BFO** off. When using crystals for calibration, set the receiver to the crystal frequency with the **BFO** on and zero beat the **BFO** in the receiver. Align the **VFO** for zero beat without changing the receiver tuning and the **VFO** frequency will be the same as the crystal frequency. Aside from this difference, the following procedure may be used for either method of calibration. Refer to Figure 20 for location and identification of the various calibrating adjustments.

NOTE: It should be noted that the trimmer capacitors (**A**, **C** and **E** in Figure 20) are used to set a definite frequency point on the dial, while the coil slugs (**B** and **D** in Figure 20) determine the overall frequency range covered by the dial. The capacitors are set to a particular frequency near the low end of the band and the slugs are adjusted so that the high frequency end of the band coincides with the dial reading. These two adjustments interact with each other and therefore should be adjusted alternately until optimum overall calibration is obtained.

Set the **VFO** to 1750 kc if a frequency meter is used or to the crystal frequency used near the low end of the band. The main bandswitch may be left in the 160 meter position for either 160 meter or 80 meter crystals.

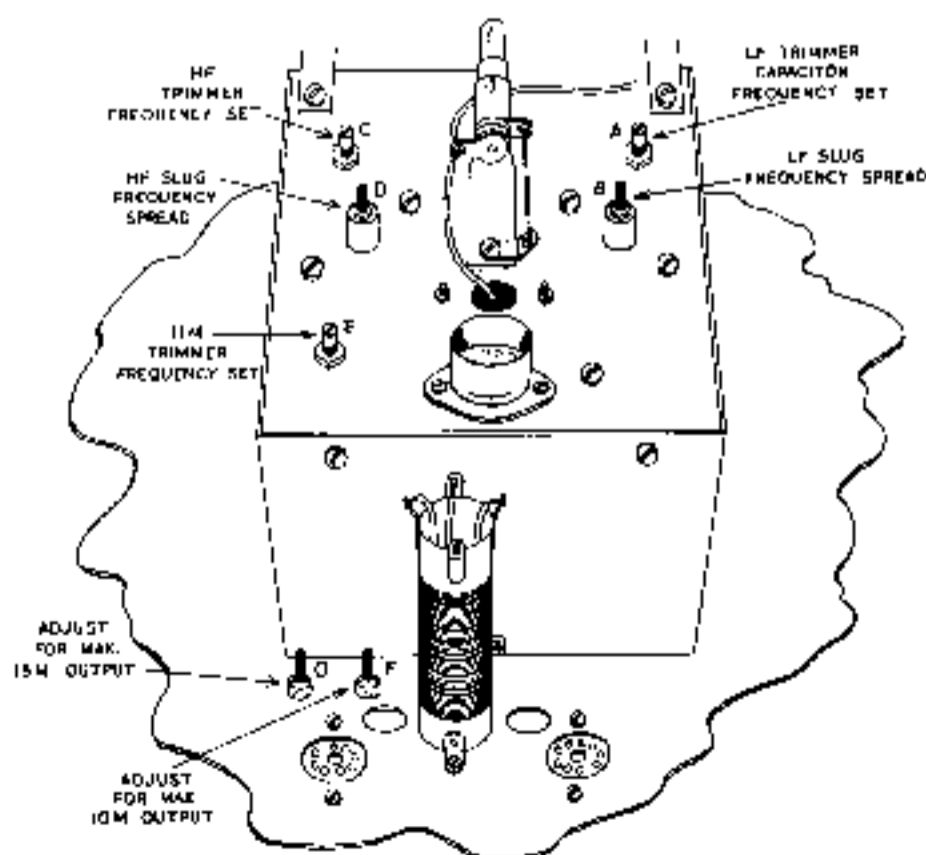


Figure 20

Adjust trimmer A for zero beat in the receiver. Note that the zero beat will be against the frequency meter if available or against the receiver BFO as previously set to zero beat against the crystal oscillator. Now use a crystal near the high end of the band or move the frequency meter up to a frequency of approximately 2000 kc. Reset the receiver as in the previous step. Tune the VFO to the high end of the band and note the reading on the calibrated dial scale. If the dial calibration exceeds the frequency used, adjust slug B clockwise. If the dial reading is less than the frequency used, adjust slug B in a counterclockwise direction. Then go back to the low frequency end and readjust trimmer A. Repeat the process until calibration is achieved at both ends of the band.

Adjust A at High end
Adjust B at low freq end of band
Repeat the procedure outlined above for the higher bands. Move the bandswitch to the 40 meter position and leave all other controls the same. The receiver and signal sources (crystal or frequency meter) must operate between 7 and 7.425 mc. Trimmer C and slug D in Figure 20 operate the same on this band as trimmer A and slug B on the lower band.

For 11 meter calibration, set the band selector to the 11 meter position and use a signal source (either a crystal or frequency meter) between 6740 and 6807.5 kc. Trimmer E only is used to zero beat the calibrating frequency against the dial reading at 27 mc on the VFO dial. This completes the VFO calibration procedure.

ADJUSTMENT OF BUFFER COILS

Set the bandswitch to the 10 meter position and the VFO dial to 28.8 mc. Advance the DRIVE control until a grid current reading can be obtained on the meter when tuning the driver stage for a peak. Adjust slug F (as shown in Figure 20) for a maximum reading on the meter.

Now switch the band selector to 15 meters and set the dial to 21.3 mc. Peak the driver stage again and adjust slug G for a maximum reading on the meter.

IN CASE OF DIFFICULTY

Mistakes in wiring are the most common cause of difficulty. Consequently, the first step is to recheck all wiring against the pictorials and schematic diagrams. Often having a friend check the wiring will locate an error consistently overlooked.

Also, with miniature sockets there is a possibility of shorts between adjacent socket terminals due to the close spacing. This should be checked and if any doubt exists, the terminals should be pried apart until obvious spacing can be seen between them.

Sometimes apparently good solder connections will have an insulating coating of rosin between the wire, the terminal and the solder. This is often the case when insufficient heat was applied in soldering. An ohmmeter check of any questionable connections will test for this condition. Naturally, all voltages should be "off" for such tests.

The transmitter is fused at the line cord plug. A type 3AG fuse is required on each side of the line plug with a rating not in excess of 8 amperes. Should it be found that fuses consistently blow whenever the equipment is plugged in and the POWER switch is turned ON, resistance tests of the low voltage power supply should be made in accordance with the following chart. If a fuse blows whenever the PLATE switch is moved to the ON position, the high voltage power supply should be checked with an ohmmeter as outlined in the chart on Page 54. In either case, it is important that the power switches be OFF and the line plug removed when the resistance measurements are made. As additional insurance against shock, a screwdriver blade should be used to short from the chassis to the hot end of the bleeder resistor and from the chassis to each of the filter condensers so that they will be thoroughly discharged.

Be sure to reread the circuit description on Page 3 so that "cause and effect" reasoning may be employed as the search for trouble progresses. If some difficulty still persists after the steps outlined have been completed, attempt to localize the trouble to a particular stage in the transmitter circuit. Use the tuning procedure as a basis for localization and refer to the block diagram and schematic to visualize circuit relationships. The panel meter and station receiver are extremely valuable tools to use in locating trouble.

RESISTANCE MEASUREMENTS

TEST CIRCUIT	TEST POINT	OHMS TO GROUND
Low Voltage Supply	Low Voltage Filter	32 K Ω
High Voltage Supply	High Voltage Filter	30 K Ω
Bias Supply	Pin 2 or 7 6AL5 tube	5.6 K Ω
Final Grid Circuit	6146 Grid Bus	6.7 K Ω
Oscillator Screen	Pin 8 12BY7 tube	60 K Ω
Modulator Screen	Pin 3 1625 tubes	15 K Ω
Final Amplifier Screen	Pin 3 6146 tubes	52 K Ω

If a grid current reading cannot be obtained at the panel meter, the receiver may be used to check VFO and/or crystal oscillator operation. Connect a short piece of insulated wire to the receiver antenna terminal and bring the wire near the VFO or crystal oscillator tubes. Tune the receiver to determine if a signal is being generated by the respective oscillator circuits. If no signal is present, check the tubes and notice the OA2 voltage regulator tube to see if it has a blue glow. If the OA2 shows blue, B+ is present. If this tube is dark, check the B supply. If only one of the oscillator circuits works, check the XTAL-VFO switch wiring.

If it should be determined that both oscillator stages are functioning properly, but still no grid drive can be obtained on the meter, turn the meter switch to the DRIVER position and advance the DRIVE control fully clockwise. The meter should read upscale, indicating plate current in the driver stage. No reading shows a defective driver tube, lack of DC operating potentials on the driver stage, an open cathode, screen or plate circuit, lack of coupling between oscillator and driver stages or detuned oscillator coils.

If, on the other hand, driver plate current can be obtained on the meter, try adjusting the DRIVER control for a dip in plate current. No dip could be caused by improperly connected driver tank coils or a poor connection to the driver tuning capacitor.

Should it be found that a dip can be obtained in driver plate current when tuning the driver, but still no grid current is available, the 6146 grid circuit may be open at some point. Note that the grid circuit includes a 1.1 mh RF choke, a shunt resistor for the meter, a 2.2 K Ω grid resistor and bias supply bleeder resistors. If an ohmmeter is available, measure the overall grid circuit continuity with the power turned off. The reading should be in the vicinity of 6.7 K Ω . If such a test shows an open, check each grid circuit component separately to find the defective component or connection.

Assuming that grid current is available in the correct quantity, difficulty in the 6146 stage may manifest itself in the form of an excessive plate current reading, insufficient plate current or inability to obtain resonance when tuning the final amplifier.

Excessive plate current could indicate a shorted RF bypass condenser in the final stage, lack of grid bias, detuned final tank circuit or miss-set loading control.

Insufficient plate current would suggest low plate voltage and this can easily be checked with the panel meter in the VOLTS position. If plate voltage is present but plate current is still low, the clamp control may be miss-set (see tuning procedure for proper adjustment) or the screen circuit may be shorted or open.

Failure to reach resonance when tuning the final tank circuit could indicate an incorrectly wired bandswitch or loading switch, a shorted loading capacitor or any other short or ground in the final pi-network circuit. Also, do not overlook the possibility that the frequency controls in previous stages may be incorrectly adjusted (see tuning procedure).

AUDIO CIRCUITS: Inability to obtain modulation when following the procedure outlined in the tuning instructions could be indicative of trouble in the speech amplifier or modulator circuits, or may simply show a defect in the microphone or cable. Isolate the trouble by disconnecting the microphone connector at the panel. Move the meter switch to MOD. and set the audio GAIN control fully counterclockwise. Touch the center portion of the microphone connector on the panel with your finger and advance the audio gain control slowly. The meter will show modulation if the speech amplifier and modulator circuits are all right, pointing to trouble in the microphone or cable. No reading at all on the meter suggests a lack of screen voltage on the modulator. Check the wiring at the CW-PHONE switch. Screen voltage is obtained at the center tap of the bleeder resistor. If the meter reads up to about 50 milliamperes, however, but does not increase above this value with signal input, the trouble is more than likely in the speech amplifier portion of the circuit.

With the high voltage PLATE switch OFF, speech amplifier output can be checked at the modulator control grids. Care should still be exercised, however, because the low voltage power supply is still on. Connect a headphone or an AC voltmeter from grid to grid on the two modulator tubes and apply audio signal to the input of the speech amplifier by touching your finger to the center part of the microphone connector on the panel. No output under this condition could mean that one of the speech amplifier tubes is defective. Have them tested or substitute new ones. The speech amplifier portion of the transmitter is straightforward audio circuitry and the conventional test procedure for such circuits can be applied. Access to this portion of the circuit may be had by removing all screws from the audio shield plate under the chassis. Remove the screws that hold the plate to the chassis and those that hold the terminal strips on the plate and the plate may be removed without any difficulty. The circuit components will support themselves temporarily.

CABINET ASSEMBLY

- () Place a soft cloth over the workbench or table top so that the paint on the cabinet parts will not become scratched during assembly.
- () Refer to Figure 21 on Page 56 to identify the cabinet sections. Note the difference between the end bells as shown in the figure. Select the right end bell and place on the table with the front toward you as in Figure 22 shown in Page 57.
- () Figure 21 will reveal that the two back corners of the cabinet are the same. Select one of these corners and install as shown in Figure 22A. Use the blunt pointed sheet metal screws and speednuts to fasten these parts together.
- () Figure 22B shows how the corners and panels are interlocked. With this in mind, mount the back panel with the holes to the left as shown in Figure 22C. Use the same type sheet metal screws with speednuts for this and all subsequent assembly steps.
- () Now install the other rear corner in the same fashion, making sure that it interlocks with the back panel.
- () Select the top panel and mount as shown in Figure 22D, again making sure that the panel interlocks with the corner.
- () Now select the top front corner and note that it differs from the back corners and the bottom front corner. Install it as shown in Figure 22E, interlocking with the top panel.
- () Now install the bottom panel and the remaining front corner as shown in Figure 22E.

- () Install the left end bell using the same hardware as with the right end bell. Make sure that each corner is interlocked with its adjacent panel or panels before tightening screws. This can best be accomplished by placing the left end bell down flat on the table and lowering the rest of the assembly onto it.
- () Complete the cabinet by installing the bottom rails and rubber feet as shown in Figure 22F. Use the large #10 sheet metal screws through the feet, the bottom panel and into the rails.
- () The transmitter can now be installed in the cabinet. Place the transmitter chassis in front of the cabinet and pass the line cord plug through the left hole in the back panel. Now slide the transmitter chassis onto the rails and into the cabinet while guiding the line cord through the back hole. Use ten #10-32 phillips head screws to fasten the front panel to the case and eight #10 sheet metal screws through the back panel of the case into the back chassis apron.

INSTALLATION AND OPERATION

NOTE: It should be noted that an Amateur Radio Operator and Station License is required to place this transmitter on the air. Information regarding licensing and amateur frequency allocations may be had from publications of the Federal Communications Commission or the American Radio Relay League.

This transmitter can be used for novice operation only if the following three requirements are met: (a) CW operation only. (b) Crystal control only, on assigned novice frequencies. (c) Reduced output power - plate power input must be kept below 75 watts by light loading on the final amplifier stage. Plate current should be held below 90 to 95 milliamperes.

GROUNDING: The importance of a good ground that presents low impedance at all frequencies cannot be emphasized too strongly. What may be a perfectly satisfactory ground at 160 meters could place the transmitter considerably above ground at the higher RF frequencies. As an example, the length of the ground wire is sometimes critical. An 8 foot wire from the transmitter to ground would be a direct short at 160 meters but becomes one-quarter wave length at 10 meters and therefore places the chassis at a high RF potential. Some hints that will be of assistance in obtaining a good ground are:

1. Connection for the ground should be made to cold water or well pipes and/or multiple pipes or rods driven approximately eight or more feet into moist earth. A salt solution poured around the ground rods will further increase the conductivity to ground. A more elaborate installation might include a system of wires approximately one-quarter wave length long laid a few inches under the surface of the earth in a grid or radial pattern. The use of one or all of these grounding systems may be combined to form a good ground reference.
2. The electrical connection to the ground point should consist of a short heavy conductor (#12 wire or heavier, or copper braid). If a short ground wire is difficult to obtain because of transmitter location, several leads of random length may be used. The use of random leads lessens the possibility that all leads should become one-quarter wave length at the frequency of operation. If the transmitter becomes hot at one particular frequency, the addition of a ground wire cut to one-half wave length at this frequency may clear up the difficulty.

Some of the symptoms of inadequate grounding are manifested in the form of:

1. Inability to load the antenna properly.
2. High RF potentials on the chassis or case of the transmitter.
3. Undue voltage strain on output circuit components.
4. Final plate current reading affected by touching the panel or case.

LOCATION: The transmitter should be located where free circulation of air is possible and objects should not be placed on the case as this might restrict the circulation of air. Good ventilation is essential to insure maximum component life. A table or desk of adequate strength must be used to withstand the weight of the transmitter. The considerations mentioned with regard to grounding will also affect the selection of a good location, as will the point of entry of the antenna feeder.

OPERATION: The tuning procedure outlined previously will also apply when loading an actual antenna. Some special cases involving particular antenna types will require special consideration and will be covered under **ANTENNAS**.

A point not covered under the tuning procedure is the method by which the VFO may be beat against an incoming signal without placing the transmitter on the air. This is desirable to place the transmitter on the same frequency as the received signal. When operating phone, with the **PLATE** switch OFF, move the **CW-PHONE** switch to **CW** position. This energizes the first three stages of the transmitter circuit. Enough signal will ordinarily be picked up by the receiver under these conditions that the VFO can be tuned for zero beat on the receiver with the incoming signal. If the frequency excursion is more than a few kilocycles, it will be necessary to retune the driver stage. Return the **CW-PHONE** switch to **PHONE** position. When the transmitter is again placed on the air, the final amplifier tuning should be touched up appropriately to compensate for the frequency change.

When operating **CW**, simply depressing the key (with the **PLATE** switch OFF) will allow the operator to zero beat with the incoming signal on the receiver. Here again, if the frequency change is more than a few kilocycles, the driver and final stages should be retuned as outlined previously.

REMOTE CONTROL SOCKET: See Figure 23 for a diagram of this socket. This is the octal socket located on the back chassis apron. It provides connections for external duplication of the functions of the plate switch and provides 110 volts for antenna relay or receiver muting relay operation when the plate switch is on. In addition, audio output up to 80 watts at 500 Ω can be brought out from this socket for excitation of a higher power modulator. Pin 8 provides an auxiliary ground in the event that shielded cable is used for remote operation.

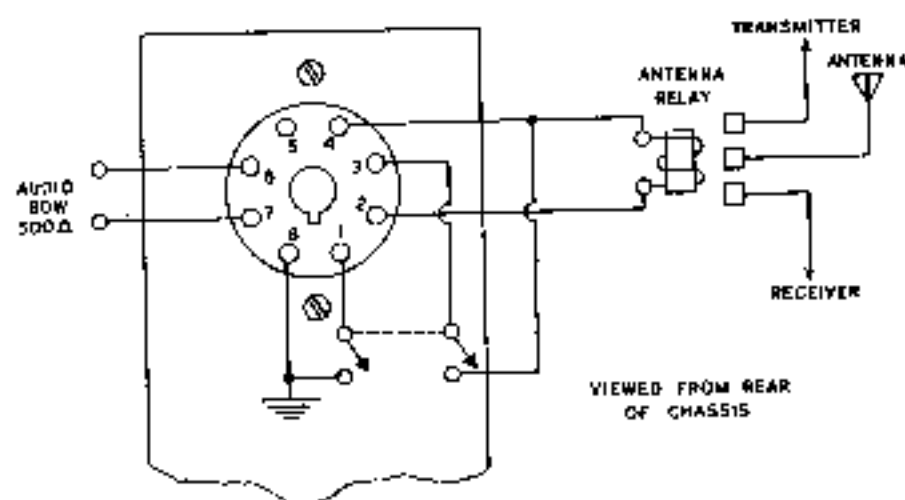


Figure 23

Should the **DX-100** be used as an exciter for a larger transmitter, RF excitation is available at the antenna output connector. Audio at 500 Ω is available at the octal socket providing a slight circuit modification is first accomplished. To do this, refer to Pictorials 2 and 5 and locate terminal strip **FF** on the chassis base. To remove the high voltage from the modulation transformer secondary, clip the jumpers between lugs 1 and 2 and 4 and 5 on strip **FF**. Install jumpers between lug 3 of **FF** and lug 1 of **GG** and between lug 4 of **FF** and lug 3 of **GG**. Then audio will be available between pins 6 and 7 of the remote socket.

An external switch may be placed in parallel with the plate switch by connection to pins 3 and 4 of the remote socket. When using a remote plate switch for phone operation, a double pole-single throw switch or relay must be used to perform the full function of the plate switch. One set of contacts completes the circuit between pins 3 and 4 of the remote socket, while the other set completes the circuit at pins 1 and 8.

For operation of an antenna relay or receiver muting relay, 110 volts is available between pins 2 and 4 of the remote socket when the plate switch is on and is removed when the plate switch is off.

ANTENNAS: The pi network output circuit of the model **DX-100** will match pure resistive loads from approximately 50 to 600 Ω . The coarse loading step-switch and the fine loading adjustment will match all impedances within these limits. Therefore the transmitter will match antennas and unbalanced lines within these limits, also, provided such antennas or lines are non-reactive. Reactive antennas or lines present a somewhat different problem, however, since the reactance takes the form of impedance which may raise or lower the antennas impedance beyond the matching range of the transmitter output circuit.

Balanced antenna systems should be fed through an antenna coupler so that neither leg of the line nor the antenna will be at ground potential. Normally the output of the transmitter is unbalanced since one side of the output circuit is grounded.

When loading to either a balanced or an unbalanced system, the maximum loading point of 250 milliamperes in the final stage should not be exceeded. In many instances, the transmitter will load to a higher level, but the harmonic suppression of the pi network is better if the output coupling capacitor is not reduced to absolute minimum value. Then too, the extra 10 or 15 watts which would be gained by maximum loading would not make any appreciable difference at the receiving end of the transmission.

END-FED HERTZ AND MARCONI ANTENNAS

This type of antenna consists merely of a single wire from one-fourth wave length long to any even multiple thereof. One end of the wire is coupled to the transmitter and the other end supported in space. If this antenna is operated against ground, it is known as a Marconi antenna, while if the length is one-half wave length or more, it is known as a Hertz antenna. The greatest disadvantage of feeding a single wire is the necessity of bringing part of the radiating element into the radio room where its proximity to nearby objects increases losses. The greatest advantage of such an antenna is the simplicity with which it may be constructed and its compact size where space is at a premium. Providing the reactance of such antennas is not excessive, they may be loaded satisfactorily with the pi network output circuit of the DX-100.

The length of such antennas should be calculated from the information given in the Radio Handbook or the ARRL Antenna Manual. Random lengths may also be used effectively except for some critical antenna lengths where the antenna impedance becomes too high or too low to be matched satisfactorily at the output of the transmitter. When such a situation is encountered it can usually be recognized by the action of the loading controls on the transmitter. Should it be found that increasing the loading (reducing the output coupling capacitor value) does not raise the final amplifier plate current reading on the meter and yet the final amplifier has not become fully loaded, it is very likely that the antenna being used has a higher than normal reactance at the frequency of operation, resulting in the transmitter looking into a higher overall impedance.

If it is found that a change in coupling capacitor value has little effect on the final amplifier loading and does not affect the final amplifier tuning in the normal fashion, the antenna in use is probably presenting lower than normal impedance to the transmitter.

When the antenna impedance is too high or too low for satisfactory loading, the situation can usually be remedied by changing the length of the feedline to the antenna, the length of the antenna itself or the point at which the feedline is connected to the antenna. Small changes, not to exceed one-quarter wave length should be effective in correcting the impedance mismatch.

Another cure for such difficulty would be to introduce inductance or capacitance in series with the antenna and feeder to cancel out the undesirable reactance in the antenna. Of course, a more elaborate method would be the use of an antenna tuner if some element in the situation made it impractical to employ the methods outlined above.

BALANCED ANTENNA FEEDERS AND SYSTEMS

In the average station it will be found expedient to have the radiating portion of the antenna some distance from the transmitter. This statement assumes that the amateur will have his antenna up high and clear of nearby objects, whereas the actual transmitter may be in the basement or any other room in the home. In such a case, some form of transmission line must be used to efficiently connect the transmitter to the antenna. In many instances, the transmission line is of the "balanced" type in which neither leg of the line is grounded. Such transmission lines may be either tuned or untuned, but in either case, a balanced line must be fed through an antenna coupler or "balun" coils. The coupler also provides the means for matching the impedance of the antenna, which will vary depending upon the type of antenna employed. A typical antenna coupler circuit is shown in Figure 24 on Page 61.

Basically the antenna coupler is an impedance transformer, transforming the impedance of the transmitter to the impedance of the transmission line and antenna system. Referring to Figure 24, coil L1 should match the impedance of the coaxial cable as closely as possible at the frequency of operation. The circuit consisting of L2, C1 and C2 must tune to the transmitter frequency. If it is desired to series tune the antenna, the shorting bar between 3 and 4 is opened and the transmission line connected at these points. For parallel tuning, 3 is shorted to 4 and the transmission line connected to 1 and 2. Taps are provided on the coil L2 to facilitate matching the transmission line.

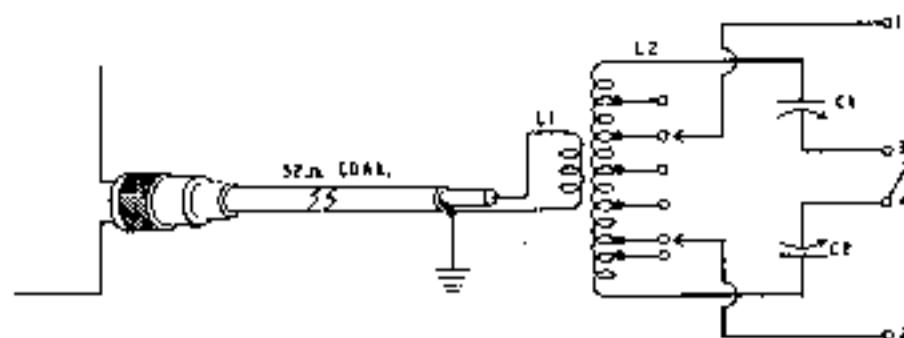


Figure 24

Such a unit can be built up from this or other suggested circuits or may be purchased commercially as a completed unit. In any case, feeding folded dipoles, end-fed "Zepps" and similar antenna types will require an antenna coupler or balun coils since the normal output of the DX-100 is designed for single-ended, unbalanced operation.

LOW PASS FILTERS: The harmonic rejection of the pi network output circuit of the DX-100 is excellent and will attenuate harmonics considerably when the transmitter is properly grounded and carefully tuned. However, additional harmonic attenuation may be had with the use of a low-pass filter between the output of the transmitter and the feed line or antenna. Such a filter should be designed to handle the maximum power output of the transmitter and must be operated into its nominal impedance.

Needless to say, no attempt has been made here to cover the theory of antennas, as such, since much has been written on this subject. The possibilities in different antenna types and different feed systems are many and the factors mentioned herein only scratch the surface of the subject. Each operator will need to do his own investigation into the advantages and disadvantages of the various systems to determine just which one will best suit his needs. Basic data is available through the Radio Amateur Handbooks and other technical publications.

Some formulas that should prove helpful are listed as follows:

$$1 \text{ wave length in space} = \frac{300,000 \text{ meters}}{F_{kc}}$$

$$\text{Center fed dipole one-half wave long (length in feet)} = \frac{468}{F_{mc}}$$

$$\text{Folded dipole one-half wave long (length in feet)} = \frac{462}{F_{mc}}$$

$$\text{Zepp antenna one-half wave long (length in feet)} = \frac{492}{F_{mc}}$$

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

- A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
- B. Identify the type and model number of kit in which it is used.
- C. Mention the order number and date of purchase.
- D. Describe the nature of defect or reason for requesting replacement.