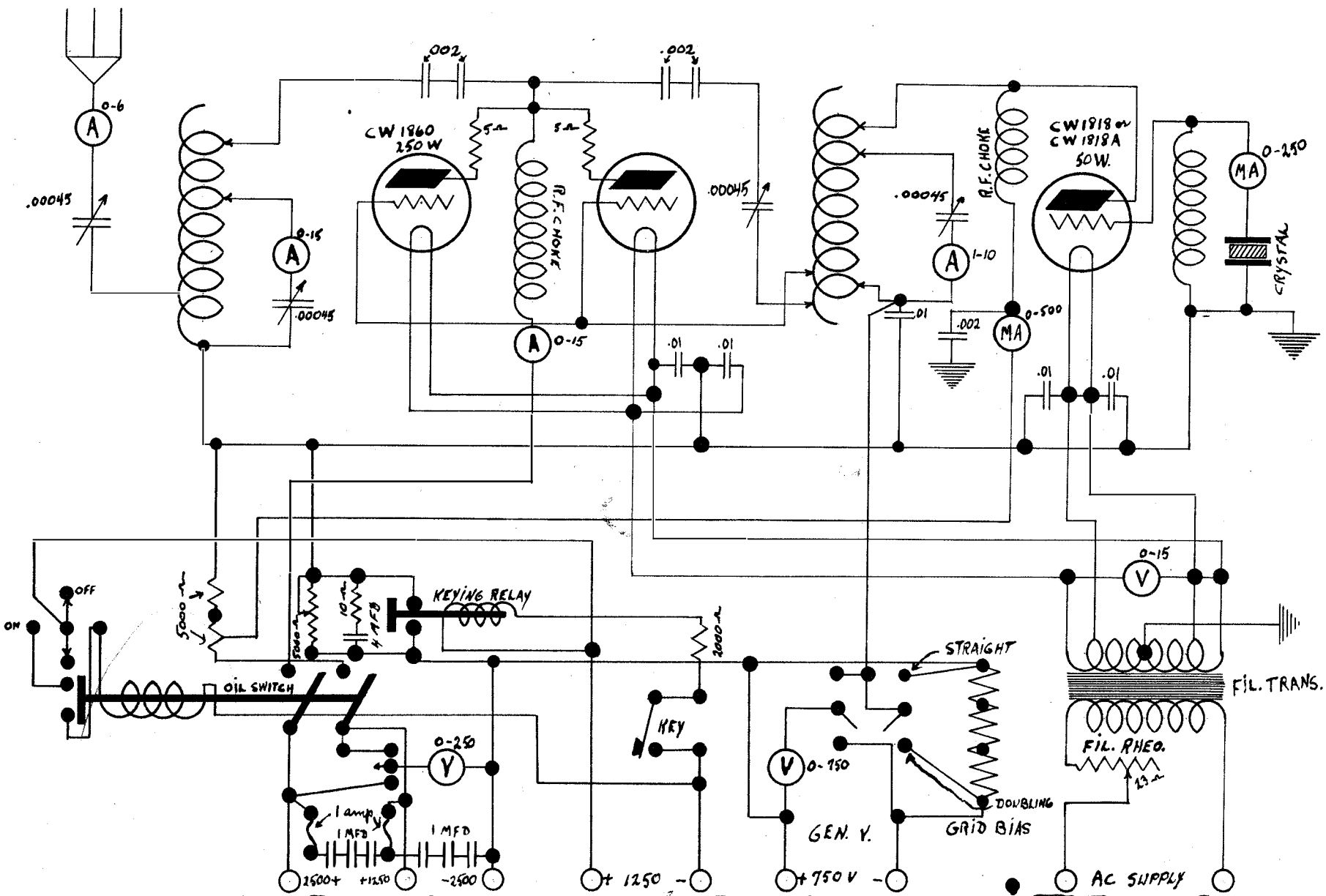

MODEL "XA" TRANSMITTER

TWENTYFOURTH WEEK. G.B.Todd,RM1c.
XA & XA TRANSMITTERS.

QUESTION #1. Upon how many different frequencies can the XA transmitter work? Explain how it is done.

ANSWER #1. Two frequencies are assigned to each transmitter and four crystals are supplied so that each set will have a crystal and a spare for each frequency. The power amplifier can be tuned so that it will amplify the fundamental of a crystal, the double, or the triple of each crystal frequency. It is thus seen that the set can work on any one of six different frequencies. As an example: If the set is assigned 8070 and 8350 KCS, a crystal is furnished for each of these frequencies, the power amplifier can be so tuned that it will amplify the double of 8070, or 16,140; or the triple of 8070, or 24,210; or the double of 8350, or 16,700; or the triple of 8350, or 25,050 KCS.

QUESTION #2. What is the capacity in power of the XA transmitter?

ANSWER #2. The Model XA crystal-controlled high frequency transmitter is designed for an output of 500 watts.

QUESTION #3. What type of tubes are used in the XA transmitter and how are they connected?

ANSWER #3. The circuit used is a crystal-controlled Master-Oscillator Power-Amplifier. A 50-watt CW 1818 or CW 1818 A vacuum tubes is used in the master-oscillator to generate the oscillations. Only these types of tubes will do the work. The oscillations are amplified in the power amplifier by two 250-watt, type CG 1860 A vacuum tubes, which are connected in parallel.

QUESTION #4. What care should be given the crystals?

ANSWER #4. Extreme care must be used in the handling of crystals as they are very sensitive and quite fragile. The holder should be shaken very lightly, if the crystal will not oscillate. The holder should not be opened unless it is found that it is absolutely necessary. And even then it should be immediately replaced after the trouble has been remedied in order to keep out all moisture and dust, as the least bit of moisture or dust on the crystal will sometimes keep it from oscillating. If the operation of the crystal is intermittent, that is, it operates at the start and then stops, the trouble may lie in faulty adjustment of the transmitter, or poor tube in the master-oscillator circuit. If it is found necessary to open and clean the crystal, remove the crystal from the holder only after studying the relative position in the holder in order that it may be replaced exactly the same way. Clean the crystal with a soft white rag and pure alcohol or clean carbon tetrachloride from a Pyrene fire extinguisher. Any grease on the crystal will prevent it from oscillating. If the grid RF milliamperes have exceeded 120 at any time, the crystal may be cracked.

QUESTION #5. What kind of an antenna and what length is used in the XA transmitter?

ANSWER #5. The antenna used with an XA transmitter is a single wire vertical antenna approximately 75 feet in length, altho experiment with the length will obtain the correct length. A change of two feet one way or the other will make a great difference in the antenna current. To determine the correct length, start with an antenna about 75 feet long, measuring from the insulator on top of the set out to the insulator at the other end. No. 8 or No. 10 hard-drawn bare copper wire is best. The antenna should be shortened by two-foot steps, retuning the transmitter each time, until the length is decreased to about 67 feet There should be one length where the greatest antenna current will be obtained. If no great change is obtained below 75 feet, it is a good idea to try 77 or 79 feet, and, if the desired length is found, where the maximum antenna current is obtained, the antenna should be made up permanently to that length. It is then of the proper length for efficient radiation on the fundamental, double, or triple crystal frequency.

QUESTION #6. Describe the Model XC tube transmitter.

ANSWER #6. The Model XC is a 250-watt high frequency tube transmitter. The dimensions of the transmitter are:- length, 24 inches; width, 14 inches; and heighth, 27 inches. A bakelite panel is mounted on the front of the transmitter and contains all of the apparatus necessary for control and adjustment, together with all meters necessary for operation. The controls for: a variable condenser to tune the crystal circuit; a variable condenser to tune the power-amplifier circuit; a variable condenser to tune the antenna circuit; two rheostats, one for the filament of the oscillator tube, and the other for the filament of the power-amplifier tube; the names of all meters, variable condensers and rheostats; are all on this front bakelite panel. The condenser for neutralization is mounted on a bakelite subpanel on the left side of the transmitter. On the rear of the set, near the bottom, is located a terminal board with terminals for connecting up the filament and grid biasing batteries, plate supply, key, and ground. The antenna is connected to the terminal on top of the isolantite insulator on the left side of the set and the counterpoise is connected to the terminal on top of the isolantite insulator on the right side of the set. All the units that go to make up the crystal controlled oscillator are inclosed in an aluminum box located behind the panel at the top of the set. This completely shields the oscillator circuit from the power amplifier circuit and prevents feed back, due to inductive coupling.

QUESTION #7. How many and what kind of meters are installed on the XC transmitter? Explain what these meters are used for.

ANSWER #7. There are six meters used on the XC transmitter. Two of these are radio-frequency ammeters; one for indicating the current in the tuned circuit of the crystal oscillator, and the other for indicating the current in the antenna circuit. There are also two voltmeters, one for indicating the filament voltage of the oscillator tube and the other for indicating the filament voltage of the power-amplifier tube. Two milliammeters complete the meters, and one of these is used to indicate the plate current of the oscillator tube and the other for indicating the plate current of the power-amplifier tube.

QUESTION #8. Give the color scheme used on the different circuits of the XC transmitter.

ANSWER #8. The leads connecting the different parts of the circuit in the Model XC transmitter are painted so that the different circuits can be readily traced out. The following color scheme is used. All leads in the antenna circuit ar painted blue; ground circuit, black Tuned circuits, yellow; Plate circuits, red; Grid circuits, green; and Filament circuits, brown.

QUESTION #9. What are the antenna currents on 4,105 and 8,210 KCS on the XC transmitter?

ANSWER #9. If the size and location of the antenna is the best obtainable, that is, corresponds to the size and location of the antenna used when the tests on this transmitter were conducted, the antenna current on 4,105 KCS should be between 2.5 and 3.5 amperes; and on 8,210 KCS, between 1.5 and 2 amperes.

QUESTION #10. Describe in detail the power unit used on the XC transmitter.

ANSWER #10. The motor is 120 volts DC and the generator is 2000 volts DC. To set up, connect 120 volt line to L and L1, positive to L1, and through an external line switch, connect C1 and C2 together. If not, asmall SPST switch must be supplied to connect across C1 and C2. There are no external rheostats supplied. If it is desired to work at reduced voltage for tuning or other purposes, insert a resistor of about 150 ohms in generator field lead. This will reduce generator voltage to about 1300. To protect the generator against small overloads a circuit breaker is provided on generator to trip at .5 amp. Should this fail the lower relay will open. In starting, the left relay closes and at the same time lower relay opens. When current falls to safe value lower relay closes and this closes the relay at right. In running position both are closed. Any surge on generator of .75 amps will cause lower relay to open, thus opening right relay and opening generator field. An 80 volt motor is also furnished for the 2000 volt generator where that current is available.

DETAILS OF XA AND XC TRANSMITTERS NOT COVERED BY QUESTIONS.

XA.

Tuning and Operation:- 1. Insert one crystal of your assigned frequency in the front set of clips. The first tuning operation will be to adjust set to radiate on the "double" frequency. 2. Remove 2500 volt lead marked with small tag from oil switch in back, lower part of set. This takes all plate voltage off power-amplifier tubes and should, naturally, only be done with all motor generators shut down. Tie up end of lead so it can not touch anything. 3. Start up motor generators, always pushing the switches in this order: "grid gen." "plate gen." and "filament voltage." The plate voltage switch controls the oil switch and opens and closes the 1250 and 2500 volt supply leads. It should always be the last switch thrown in and should be the first one thrown to "Off" in shutting down the set. Remember, in starting, push the switches from right to left and in closing left to right. Adjust filament to 11 volts and the plate and the grid voltages to the values shown in the instructions submitted with the set. Adjust condenser dial B to zero (balance is not needed in doubling or tripling) and dials A, C, and D to values given in instructions for "doubling" on the frequency of the crystal you are using. Put power amplifier wave changer on position "2" and grid tap from power amplifier tubes on master coil to turn shown in instructions for doubling frequency. Throw switch on lower panel marked "Grid volts" to "doubling" position, and, with key down, adjust negative grid voltage to value shown in instructions table. 4. Push "plate-voltage" switch on. The crystal should now oscillate as shown by current indications in both meters (crystal radio-frequency amperes and grid radio-frequency milliamperes) If no current shows in these meters, readjust A slightly; this should bring results. Never adjust the crystal circuit so that the current in the "grid radio-frequency milliampere meter rises to or exceeds 120 milliamperes - a broken crystal will result if you do. The instructions furnished show the value normally to be expected. Also, if the crystal stops oscillating after set is all adjusted, this will usually be due to the crystal working on the peak or ragged edge. Back off A just a touch so that the current as shown in the "crystal radio-frequency amperes" meter is a little below maximum. (Make these adjustments with the key down or closed.) After the set has been warmed up in operation, it will be necessary to touch up on all of the condenser adjustments except the balance. 5. After crystal is adjusted and oscillating, shut down all motor generators and replace 2500 volt lead on oil switch. Start up motor generators and adjust plate voltage at about 1500 volts. Tap the key, watching the plate current meter of the power amplifier tubes. If the plate current does not exceed .3 or .4 ampere (300 or 400 milliamperes), it is safe to hold the key down while you touch up on the adjustment of the condenser C for maximum current in the meter marked "Power amplifier radio-frequency amperes" (Keep a careful eye on the plate amperes and tubes to see that they are not overheated. Never let your tubes get a bright red.) Next adjust condenser D to put energy into the antenna, readjusting C for maximum each time D is changed. Try adjusting the antenna tap on the power amplifier coil until the position is found for this tap and condensers C and D which gives the maximum current in the antenna. It will also be necessary to experiment with the length of the antenna as explained under question number five.

When the antenna coupling turns on the power-amplifier coil and the condenser D are set at the right position and the condenser C reset for maximum, the current in the power amplifier radio-frequency amperes meter will be much less, because the energy of the power-amplifier circuit is no longer being dissipated in the local circuit. It is being transferred to the antenna and radiated off as useful energy. It should now be possible to bring the plate voltage up to 1800 or 2000 volts without overheating the tubes or exceeding 500 mils of plate current. This is the proper adjustment. Note all settings so you can return to them at any time. 6. Repeat this procedure with the other frequency crystal for doubling and tripling, on each crystal. Note down all these settings. When you are doubling, set wave changer on power amplifier on position "2" and for tripling set on position "3"(Position 4 will not be needed at this time.) Also, shift switch on lower panel marked "Grid volts" from "Straight" to Doubling and to "Doubling" when doubling or tripling. 7. The next step is to adjust the set for operation on the same frequency as the crystal. This requires the use of a balance between the crystal master circuit and the power amplifier. The process of balancing is described below.

Balancing:- The position of the balancing condenser B, as shown in the table given with instructions, is approximately correct but will vary somewhat with the antenna used. To check this, adjust plate voltage to about 1600 volts.

Do not press key until after set is balanced.- Shift switch on lower panel marked "Grid volts" to "Straight" and move the grid tap from the power-amplifier tubes on master coil to turn shown in table for the fundamental. Set condenser B at about 10 divisions less than the value shown in the table, condenser D at about 15 and rotate condenser C until a dip is noted in the crystal plate milliamperes meter. This dip is due to bringing the plate circuit of the power amplifier into resonance with the crystal master circuit by the adjustment of the condenser C.

Now set condenser B up about 2o divisions and again rotate C through resonance, watching the plate milliameter which will again show a dip as C passes the resonance point. Somewhere between these two positions of B there should be a position where no dip is observed as C passes through resonance. This is the point of balance for that particular antenna tap and setting of condenser D. This is not necessarily the final balance position, because it is necessary to adjust the coupling between the power-amplifier circuit and antenna more accurately than given above; but such adjustment could not be carried out without at least a very close approximation of balance such as you now have.

Next set the condenser C back on the resonance point found during balancing and adjust plate voltage to about 1500 volts by means of the plate gen. field rheostat. Press the key quickly, watching the power-amplifier plate ampere meter. If the p plate current as shown by this meter does not exceed .3 or .4 it is safe to hold the key down while you touch up on the adjustment of condenser C so as to get maximum current in the meter marked "Power amplifier radio-frequency amperes" (Keep a careful eye on the plate amperes and the tubes to see that they are not overloaded never let your tubes get too red)

Next, adjust condenser D to put energy into the antenna returning C for maximum each time D is changed. If a sudden rise is noticed in plate current to the power amplifier tubes, this indicates that the balance is not correct yet and the power-amplifier circuit is self oscillating. Lift the key, and rebalance as described above for these new settings of C and D. Also try shifting the position of the antenna tap on the power amplifier coil until a position is found for this tap and the condensers D and C which gives somewhere near the antenna current shown in the table.

Remember that changing taps on the coils calls for rebalancing. When the proper balance is obtained and the antenna coupling turns and condensers D and C are correctly adjusted, the current in the power amplifier radio frequency ampere meter will be much less, since the energy of the power amplifier is no longer being dissipated in the local circuit, but is being transferred to the antenna and radiated off as useful energy. It should not be possible to bring the plate voltage up to 1800 or 2000 volts without overheating the tubes or exceeding 500 mills of plate current in the power amplifier.Note down all settings so you can return to them at any time.

XC.

Crystal control:- The Piezo electric properties of crystalline quartz make it particularly well adapted for use as a frequency standard. Plates of this material when properly cut and ground and placed in the circuit, will hold the frequency of the oscillations to extremely minute variations.

The oscillating frequency is independent of the electrical constant of the circuit and is entirely dependent upon the physical dimensions of the quartz crystal. The frequency is practically unvarying with temperature changes and is not affected by any mechanical shock which does not fracture the crystal itself Reasonable care, however, should be taken in handling the crystals as they will fracture if subjected to too great a mechanical shock. The quartz crystal is placed in series with the grid and filament of tube and the plate circuit is tuned with an inductance and capacity. When the reactance of the plate circuit is of an inductive nature the tube will oscillate and the current in the tuned circuit will gradually increase until a point is reached just above the frequency of the crystal. When the plate circuit is tuned to exact resonance with the frequency of the crystal, the tube will stop oscillating by virtue of the fact that the plate circuit is now a resistance of a very high value. As the tuning condenser is increased beyond the resonant point the plate circuit assumes a capacitive resistance and the tube will not oscillate. From this it can be seen that the best point at which to operate the crystal is found by tuning the plate circuit just above the frequency of the crystal. This will insure oscillations and maximum output.

Circuit and frequencies used:- This transmitter uses the master oscillator power amplifier circuit with a quartz crystal controlling the frequency of the master oscillator. It is designed to operate on either of two frequencies - namely, the fundamental frequency of the crystal and the first harmonic of the crystal. The crystals supplied with these transmitters have a fundamental frequency of approximately 4105 kilocycles.

Adjustments and tuning:- Before attempting to tune the transmitter, remove the lead that runs to the plus side of the plate current meter on the power-amplifier tube. Connect up the motor generator according to the wiring diagram furnished with it Connect a 12-volt storage battery, the grid biasing batteries, key, and ground to the terminal board located on the back of the set. A triple-pole switch is furnished with the set and should be connected up so that two poles are used to start the motor generator and the third pole is connected in series with the negative lead of the 12-volt storage battery.

Carefully unpack the quartz crystal and clean with carbon tetrachloride or pure alcohol and place it between the two brass plates in the glass-inclosed crystal holder which is located in the aluminum box in the upper part of the transmitter. In handling the crystal, grasp it with the fingers on the edges, as any grease or moisture from the fingers on the large flat surface of the crystal will render it inoperative and it will be necessary to clean it again.

Tuning Master Oscillator:- Although this transmitter operates on either of two different frequencies, the master oscillator is adjusted for one frequency only, and that is the fundamental frequency of the crystal. Place the clips on the coil of the master oscillator as follows: Plate clip (red) on turn #8. Grid clip (green) on turn #6. Frequency clip (yellow) on turn #12 Set primary condenser at 0°. Set neutralizing condenser at 28°. Neutralizing condenser clip (green) on turn #1 of power-amplifier coil. Close the three-pole switch which starts the motor generator and lights the filaments. Adjust the filaments by means of the two rheostats at the bottom of the panel so that the master oscillator filament reads 9 volts and the power-amplifier filament reads 11 volts. Slowly increase the primary condenser, and as this is done the primary-current meter should start to indicate current

Increase this condenser until maximum current is indicated by the primary current meter. After this point has been found, a further increase in the condenser will cause the tube to stop oscillating. Set the condenser just below this breaking point.The primary current meter should read between 2 and 3 amperes and the plate current should be not less than 55 milliamperes.The reason for this is that a resistance is inserted in series with the 2000 volt supply from the MG to cut the plate voltage down to 350 V for the master oscillator tube. The plate voltage of this tube is dependent on the IR drop across this resistance, which is 30,000 ohm With 55 mills flowing, the drop is 1650 volts which leaves 350 for the plate of the tube.

Neutralization:- It is necessary to neutralize the grid-plate capacity of the power amplifier tube to prevent any feed back through this tube capacity which would cause the tube to oscillate or regenerate. This neutralization is accomplished in the following manner: Start the oscillator tube going, being sure that both of the filaments are adjusted to rated voltage. There should be no plate voltage on the power-amplifier tube, due to the fact that the lead running to the plus side of the plate current meter has been previously removed. See that the clip running from one side of neutralizing condenser is placed on turn #1 of the power amplifier coil. The neutralizing condenser should now be adjusted until a point is reached where a variation from 0° to 100° on the power amplifier condenser does not change the plate current or

the primary current of the oscillator tube. The approximate setting for this neutralizing condenser is 28°. Each time the neutralizing condenser is changed there will have to be another adjustment made with the primary condenser, as these two are interlockir These adjustments should be made very carefully, because if the tube is not properly neutralized it will not oscillate; the oscillations will get back into the crystal circuit and in all probability puncture the crystal, rendering it unfit for further use. After the tube has been properly neutralized, the lead running to the plus side of the power amplifier plate current meter should be replaced.

Tuning antenna circuit:- The antenna circuit should next be tuned so that when the power amplifier is put in operation the antenna will absorb energy from the amplifier circuit; otherwise the plate of the power amplifier tube will have to dissipate this energy in the form of heat, which is detrimental to the life of the tube and very undesirable. In view of the fact that this transmitter is designed to operate on two different frequencies which are 4,105 KCS apart, it is recommended that two separate antenna systems be used. It is also recommended that, if possible, a counterpoise be used instead of a ground. This is especially desirable when operating on the 8,210 KC frequency, due to the fact that at these high frequencies the waves do not follow the curvature of the earth as do the lower frequencies, but travel more on an upward angle until they are deflected down again by the heaviside layer. This angle of deflection is determined by the frequency being used and gives us the so-called skip distance.

No set physical dimensions can be given for the antenna counterpoise systems, due to the fact that their electrical constants will be determined largely by their proximity to surrounding objects, such as smokestacks, metal masts, guy lines, etc. The cut-and-try method will have to be used. The following approximate dimensions are suggested for a starter: 4105 KCS: antenna 2 wires 45 feet long; counterpoise 2 wires 45 feet long. 8210 KCS antenna 1 wire 30 feet long; counterpoise 1 wire 30 feet long. The above lengths are the total lengths measured from the terminals of the transmitter. The following method should be used in getting the antenna system tuned to the approximate frequency: 1. Start up the master oscillator but do not press the key. 2. Pick up the fundamental frequency of the crystal on the receiver which is furnished with the transmitter and note the coil used and the setting of the condensers. This should be found on the large coil. 3. Next, put in the second largest coil and pick up the first harmonic of the crystal and note the condenser settings on the receiver. This gives the two known frequency points on the receiver which are to be used in tuning the antenna. 4. Couple the receiver to the antenna coil of the transmitter. Now, when the receiver and the antenna system are tuned to exact resonance the receiver will stop oscillating, which will be indicated by a sharp click in the telephone receivers. 5. If the place where the receiver stops oscillating is wide on the tuning condenser, the receiver and the antenna should be loosened until it narrows down to about one division on the tuning dial. The antenna should be either lengthened or shortened until resonance with the points on the receiver is obtained with the antenna series condenser at about 50°. Another method that can be used is as follows: Wind up a temporary coil of six or eight turns of wire and connect it in place of the antenna coil on the transmitter. Leave the leads to this coil long enough so that it can be coupled to the coil of

of the crystal oscillator tube in the aluminum box. When the antenna circuit is tuned to resonance, there will be a reading on the antenna current meter. If the plate current exceeds 225 mills it should be reduced by either increasing the plate turns or reducing the coupling to the antenna. The same method is used for the harmonic frequency. When the antenna is tuned to resonance with the first harmonic of the crystal, there will be a small reading on the antenna current meter.

Tuning the power amplifier:- The power amplifier is next tuned. See that all connections in the antenna circuit are put back correctly. Following are the approximate settings for the two frequencies used: A. 4105 KCS fundamental frequency of crystal - Antenna coil 12 turns; Power amplifier frequency clip (yellow) on turn #9; Power amplifier condenser 80°; Neutralizing condenser 28°; Neutralizing condenser clip (green) on turn #1; Power amplifier plate clip (red) on turn #11; B. 8210 KCS, first harmonic of crystal - Antenna coil 12 turns; Power amplifier frequency clip (yellow) on turn #6; Power amplifier condenser 17° Neutralizing condenser 0°; Neutralizing condenser clip (green) on turn #1; Power amplifier plate clip (red) on turn #11.

The antenna and power amplifier condenser should be carefully adjusted until maximum antenna current is obtained with a minimum of plate current. When all adjustments are properly made and the key is pressed, the primary current should stand steady or slightly decreased. It should not be allowed to increase as this is a sure sign of regeneration in the power amplifier tube. If this condition obtains, the neutralizing condenser should be carefully adjusted again until this condition stops. Also, if all adjustments are correctly made it should be possible to remove the master oscillator tube from its socket, close the key and have nothing happen in the power amplifier circuit.

DON'TS.

Don't handle the quartz crystal with the fingers, as grease or moisture will render them inoperative.

Don't fail to keep the filaments of both tubes adjusted to their rated voltages at all times.

Don't allow the plate current of the master oscillator tube to exceed 110 milliamperes or to drop below 55 milliamperes.

Don't allow the primary current to increase when the key is closed.

Don't touch any part of the transmitter when it is in operation.

Don't fail to keep the set free from dust and dirt at all times.