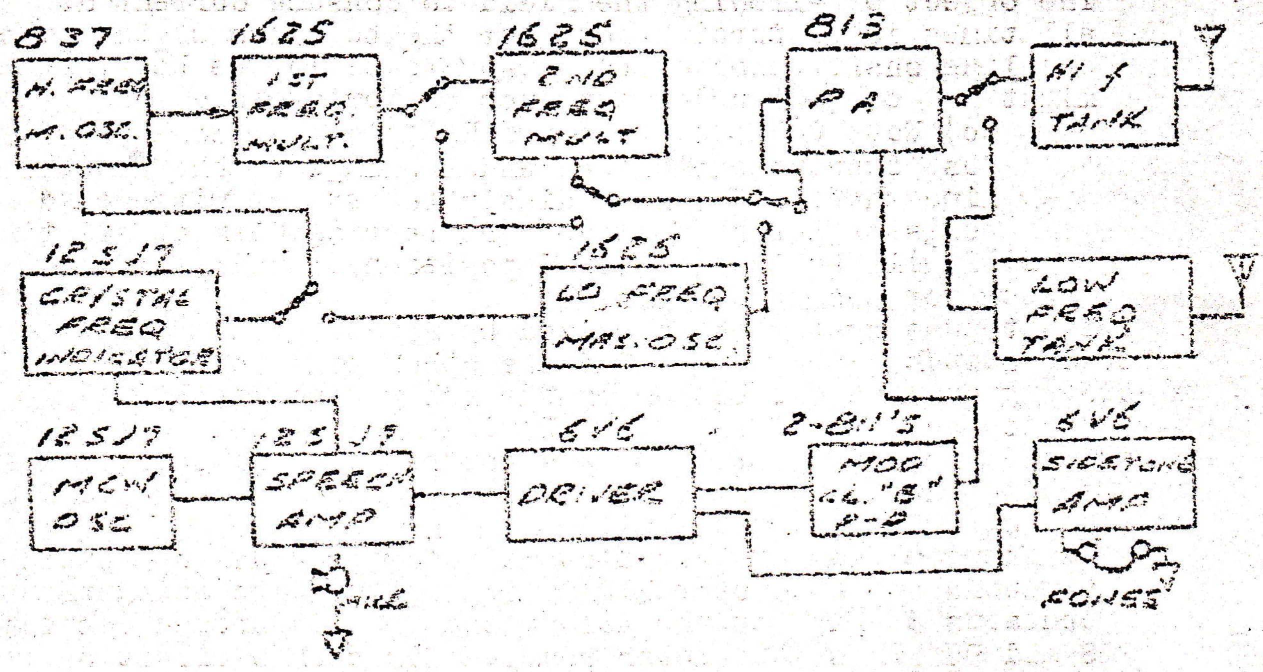
FRIDAY:

1. General description of the ATC transmitter (AN/ARC-13).
   a. The ATC is an airbourne transmitter providing transmission by CW, MCW, and VOICE. The design of the transmitter is such that a simple, accurate means of selecting any of eleven pre-tuned frequencies is supplied. The frequency coverages are from 200-1500kc. and 2000-18100 kc., utilizing two separate oscillators in combination with some frequency multiplication stages. It may be completely remote controlled.
   b. The ATC was designed by the Collins Radio Co. as a replacement for the FP and GO series of transmitters for the USN, and it is also being used in many types of USAAF aircraft.
   c. The auto-tune system is an electrically controlled mechanical tuning arrangement which automatically positions the transmitter tuning elements, comprising variable inductances, capacitances, and curcuit switches. The complete cycle of operation for selecting any one channel requires about twenty-five seconds. The precision of the system allows very accurate tuning, with complate freedom from the usual vibration difficulties encountered in aircraft. Eleven channels are available that must be set up initially; ten of the channels are in the high frequency range and the other is in the low frequency range.
   d. The ATC obtains power for its operation from the 24-28 volt DC lines in the aircraft, and consumes 37 amperes of current, average. For CW operation the gear requires 812 watts of power, MCW requires 938 watts of power, and VOICE requires 868 watts unmodulated and 1036 watts under full modulation.
2. Block diagram of the ATC transmitter.



a. The block labeled 'CFI' is a built-in Heterodyne Frequency Meter very similar to the LM series.....CFI is an abbreviation for 'Crystal Frequency Indicator'.
b. Notice how it is possible for the operator to monitor at all times everything that is happening in the audio section of the trasmitter. This is primarily necessary in order that the operator may be enabled to hear what he is transmitting when he is sending CW or MCW (the MCW oscillator works both during CW and MCW transmissions, furnishing 'sidetone' through the Speech Amp., Driver, and Sidetone Amp. stages). The output from the CFI is likewise coupled through the audio channel to the headphones, enabling the operator to obtain the usual xtal check points and frequency calibration points.
c. The low frequency tank is external to the ATC cabinet, and is required because of the comparitively large size of the inductances used in the low frequency range, 200-1500 Kc.
1. It should be noted that the low frequency oscillator and its attendant tank ckts. are seldom used, hence, the student may never see such an installation.

3. The electrical auto-tune system (refer to ATC bluepring).
a. In the static, or 'channel selected and obtained' position, the autotune system will be in the condition shown on the diagram. That is:
1. Lead screw runner at the 'top' engaging snap-action limit switch S111 in such a fashion as to close contacts 2 and 1 on that switch.
2. The tutotune relay, K101, in the deenergized position with no current applied to the B101 armature except the small torgue and heating current allowed to flow through the limiter resistor R115.
3. Notice that full current is allowed to flow through the field winding of B101 at all times, in the same direction. Motor reversal is made by reversing armature current only. The object of allowing the field to consume current at all times is to furnish heat for the bearings of the motor and line shaft in order that the grease in the bearings might not congeal under extremes of temperature.
(c) Note that the resistor R115 is located physically just beneath one of the end bearings of the autotune line shaft. The heat dissipated by the wire-wound resistor serves to keep that bearing warm at all times.
4. S112 will be in the closed position, setting-up the system for the next cycle.
b. The autotune system is energized by rotating the Channel Selector Switch, S108, to any of the other positions, which places a ground on the botton of the relay winding (K101) through contacts 2 and 12 of the Keying Relay (K102), the Circuit Seeking Tap Switch. The autotune relay is thus energized, and remains energized through its own holding contacts 5 and 6 and the bottom limit switch S112.
1. Energization of the autotune relay provides operating potential to the motor B101, positive voltage going through contacts 3 and 2 of the relay, and ground through contacts 8 and 9. Thus, the motor revolves in such a direction as to cause the Circuit Seeking Tap Switch to rotate counter-

clockwise, and the lead screw to turn so as to move the traveler down away from the upper limit switch S111. Notice that even though the Circuit Seeking Tap Switch opens up its ground once each time it revolves, that the relay still remains energized through its holding ground contacts 5 and 6, and the limit switch S112.

2. Notice that control Head B controls variable slugs in the Master Oscillator and Frequency Multiplication tanks, and hence is the frequency determining control. Because its action must be so precise, control head B rotates twenty times while the other heads rotate once, thus providing a vernier type of control.

3. The mechanism is so timed that it takes the same amount of time for all of the control heads to reach a 'home position', or starting point, as it takes the traveler on the lead screw to move from one end of the screw to the other, and opend the holding ground ckt. by opening the lower limit switch S112.

4. During the amount of slack travel time that the traveler takes to open S112, the Circuit Seeking Tap Switch S109 continues to turn until the open section of it strikes the selected channel ckt. When that happens, the last ground is removed from the relay, and it becomes deenergized, thus completeing the first half of the autotune cycle.

5. Notice that the autotune cycle cannot commence if the Keying Relay K102 is energized, because the autotune relay ckt. is dependent upon contacts 2 and 12 mating in K102. once the autotune cycle has commenced, the keying relay is immobilized by the snap-action switch, S111, which promptly snaps over to its alternate position when the traveler on the lead screw moves away from the switch.

c. The second half of the autotune cycle.

1. The Ckt. seeding Tap Switch S109 rorates only counter-clockwise, through the medium of a slipping clutch, so at the completion of the first half of the autotune cycle S109 will remian in the open ground positi n and will not move during the second half of the cycle, during which time the autune motor reverses direction of rotation.

2. Notice that when the limit switch S112 was opened by the lead screw traveler and the relay K101 was deenergized, the polarity of the voltage applied to the motor was reversed. The bottom of the motor is connected to ground through contacts 4 and 6 of K101, and the top of the motor is connected to positive 28 volts through 7 and 9 of K101, through 2 and 3 of the limit switch S111, and through 1 and 3 of the relay K101. This reversal of armature voltage, while the field of the motor remains with the same polarities, caused the motor to reverse direction of rotation, and to drive the lead screw traveler back up the lead screw. When the traveler leaves S112, it snaps back to its closed position in preparataon for the next time the system is operated.

3. During the time that the traveler is moving back up the rorating lead screw, each one of the control heads will lock into its pre-set postion by means of a mechanical cam-pawl-locking-ring combination existing in each control head.

After each head is locked into position it becomes isolated from the mechanical driving system of the autotune line shaft by means of a slippi ng clutch.

4. It takes the same length of time for all of the control heads to reach their maximum possible pre-set positions as it takes the traveler to move up the lead screw and engage the upper limit switch, S111. When the traveler strikes S111, it snaps over into its normal, or static, position, thus removing the positive actuating voltage from the armature of the autotune motor and transfering that positive potential back to the keying relay ckt.

5. By this time all of the autotune components are back in their 'static', or 'channel selected and obtained' positions, ready for the next time the system is to be operated.

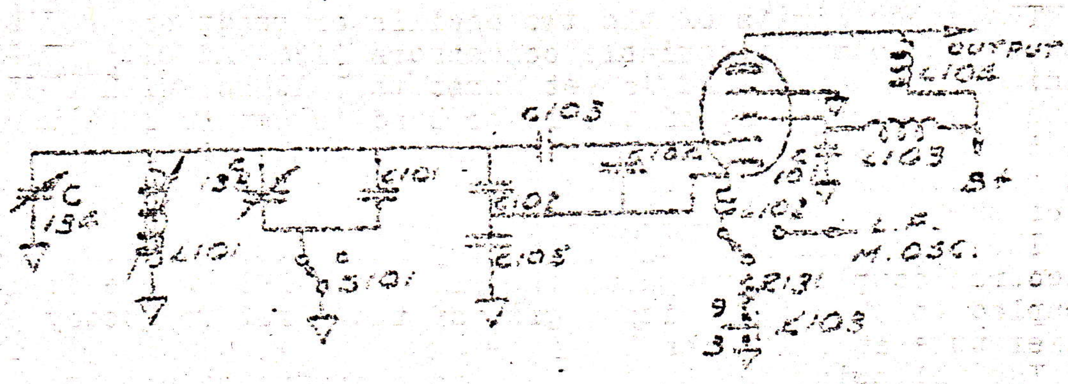
NOTE:---------the numbers designating the contacts on the autotune relay as shown on the Autotune Demo. Board do not correspond with the numbers on the blueprint of the ATC. The cross-reference is given below.

Demo-Board	Blueprint
1	5
2	6
3	4
4	2
5	3
6	1
7	8
8	9
9	7

MONDAY:

1. The high frequency master osdillator
   a. Colpitts type oscillator imployed .... refer to page 48, in the Third Week outline.
   b. The oscillator here employed is electron-coupled to the first frequency multiplication stage.

(Redrawn master osc. ckt.)



c. Notice that the switch S101, which operates off Control head A, aotually provides two basic frequency ranges for the oscillator. With S101 closed the oscillator tunes from 1000 kc. to 1200 kc., and with S101 open the oscillator tunes from 1200 kc. to 1510 kc.

d. S101 is closed in the odd numbered positions of control head A, that is, 1-3-5-etc.. S101 is open in the even numbered positions of control head A, that is, 2-4-6-etc.

e. The Colpitts voltage divider condensers ard C102 and C105.

f. C103 is the grid bias condenser, acting in combination with R101 to provide class C bias for the oscillator.

g. C104 is placed in the ckt. to stabilize, or 'swamp out' the interelectrode capacitance existing between the cathode of V101 (an 837) and the control grid of the tube. This capacity is not constant throughtout the life of the tube, nor is it the same for all 837 tubes. Variations in loading on a tube is obviously in parallel with the Colpitts bridge condenser C102, and could cause oscillator instability under some conditions. C104, being so very much larger than the input capacity of the tube, will 'swamt out ' the possible small changes in the input capacity and reduce its effect to a negligible factlr.

h. L103 in combination with C107 forms and LC filter to isolate the anode grid ckt. of the oscillator from the B plus power supply line. C107 also acts as the feedback path for the oscillator, to the bottom of the tank.

i. L102 serves to keep the cathode at a high RF potential, while providing a low resistance path for DC currents.

j. Notice that the cathode ckt. of the oscillator is keyed, as contrasted to the blocked grid keying system employed in the GO-9. The cathode ckt. of V101 goes to ground through the cam-operated switch S114 (used to change over from the high frequency oscillator to the low frequency oscillator on position 13 of control head A), the protective bias resistor R131, and contacts 9 and 3 of the keying relay, K102.

k. C106 is placed in the filament ckt. in order to ground that ckt. for RF and thereby prevent coupling through the filament line to other stages.

l. Notice that the master oscillator tank coil, and the tank coils for the two frequency multiplication stages are gang slug-tuned, by control head B, the multiturn or vernier control head. The lower limits of the two master oscillator bands are set by adjustment of the slugs.

m. The upper limits of the two oscillator bands are set by means of the small variable condensers C134 and C135. The upper limit of the high band is set first to 1510 kc. with C134, and then the upper limit of the lower band is set to 1200 kc. with C135. Both settings are made with the tank coil slug at the extreme outward limit of its travel.

2. Use of the frequency multipliers.

a. The output of the High Frequency Master Oscillator is electron coupled through to the plate of V101, where it is coupled to the signal input grid of the first frequency multiplier tube at all times.

b. The following chart will help to clarify the operation of the frequency multiplication stages in conjunction with the two ranges of the high frequency master oscillator.

Control "A"	First Multiplier	Second Multiplier	P.A.
1. lo range	dblr., 2.0-2.4 mc.	---------------	2-2.4
2. hi range	dblr., 2.4-3.0 mc.	---------------	2.4-3.0
3. lo range	trplr., 3.0-3.6 mc.	---------------	3.0-3.6
4. hi range	trplr., 3.6-4.5 mc.	---------------	3.6-4.5
5. lo range	qdrplr., 4.0-4.8 mc.	---------------	4.0-4.8
6. hi range	qdrplr., 4.8-6.0 mc.	---------------	4.8-6.0
7. lo range	dblr., 2.0-2.4 mc.	-- trplr. ----	6.0-7.2
8. hi range	dblr., 2.4-3.0 mc.	-- trplr. ----	7.2-9.0
9. lo range	trplr., 3.0-3.6 mc.	-- trplr. ----	9.0-10.8
10. hi range	trplr., 3.6-4.5 mc.	-- trplr. ----	10.8-13.5
11. lo range	qdrplr., 4.0-4.8 mc.	-- trplr. ----	13.5-14.4
12. hi range	qdrplr., 4.8-6.0 mc.	-- trplr. ----	14.4-18.0

1. The odd 10 kc. in the high range of the MO was left out of the chart for simplicity. Inclusion of that factor will bring the PA frequency up to 18.1 mc.

2. Notice that the second multiplier always acts as a tripler, and is only employed in positions 7 through 12 of control head "A". This action is provided by the two multicontact rotary switches S102 and S103, and the cam operated switch in the cathode of the second multiplier, S115, the depresed section of the cam leaving the cathode ckt. of the second multiplier open on positions 1 through 6 of control head "A", and closing the ckt. on positions 7 through 12.

3. The first frequency multiplier.

a. The output from the High Frequency master oscillator is electron coupled to the plate of that stage through the electron stream of the tube, and appears across the plate load inductance, L104.

b. The signal from the master oscillator, appearing across L104, is coupled through the condenser C108 and the parasitic suppressor R103 to the signal input grid of V102.

1. Notice that there is a 47 ohm resistor in both the signal input grid ckt. and the screen grid ckt. of V102. The object of these resistors is to suppress parasitic oscillations by adding a series resistance in the virtual tank ckts. that keep parasitic going. The suppression is caused by the fact that when a resistance is inserted in series with a tank ckt. it greatly reduces the effective "Q" of that tank, resulting in such a reduction of efficiency that it can no longer oscillate. The virtual tanks in the grid and screen cktsl, caused by the wire's ingerent inductance and capacity to ground, might cause the stage to break into oscillations at some very high frequency, thus robbing the stage of a great deal of power and practically killing its effectiveness as an amplifier ckt.

c. The multiplier stage is operated class C, bias being afforded by the combination of R102 and C108. Protective bias is provided by the cathode resistance R130. C109 is the cathode bypass condenser.

d. The plate tank of the first multiplier stage is tuned in five coarse steps by the action of the rotary switch S102, which successively throws C111A, B, C, D, E, or F across the inductance, L105.

1. Notice that the switch is so constructed that the two moving contacts are connected both mechanically and electrically, maintaining a constant number of degrees difference between the two arms at all times.

2. The moving arms of the switch are so constructed that they not only contact the individual switch contacts, but also contact the two circumferential bars at the same time. By means of the moving arm of the switch that is at "12 o'clock" on position 1 of the control head "A", the output of the first frequency multiplier is taken directly to the Power Amplifier signal grid on positions 1 through 6 of control head "A".

e. The fine, or vernier, adjustment of multiplier frequency is made by the action of the iron slug in the inductance L105. That slug is controlled by the action of control head "B", the multiturn head, which simultaneously tracks the tank ckts. of the master oscillator, the first frequency multiplier, and the second frequency multiplier by means of a mechanical coupling system.

f. As the switch S102 rotates past position 6, the output from the first multiplier no longer goes to the PA, but is transferred instead to the input grid ckt. of the second multiplier stage. Notice that in position 7, the arm that is now drawn at "12 o'clock" will have moved around to occupy the position now held by the other arm, that arm having moved to approximately 8:30.

4. The second frequency multiplier.

a. On positions 7 through 12 of control "A", the action of the rotary switch S102 is such as to cause the output of the first multiplier to be fed to the input of the second multiplier, in accordance with the chart presented on page 72 of this paper.

b. On positions 7 through 12 of control head "A" the raised portion of a cam closes switch S115, completing the cathode ckt. of V103 to ground, and allowing that stage to function.

1. The resistor R129 is placed in the ckt. to provide protective bias in the event of loss of exitation to the stage.

2. The bypass condenser C113 serves to prevent degeneration across the protective bias resistor.

c. The second multiplier stage utilizes R107 and C112 to provide class C operating bias.

d. The small 47 ohm resistor R106 is a parasitic suppressor.

e. The small variable condenser C136 is used to equalize the admittance of the second multiplier tube and the Power Amplifier stage. The input capacity of the following stage of the first multiplier is necessarily in shunt across the tank ckt. of the first multiplier....since the input capacity of the 813 PA is considerably higher that the input capacitance of the 1625 second multiplier, considerable detuning of the first multiplier tank ckt. would result from position 6 to position 7 of control head "A", if steps were not taken to provide similar loads.

f. The 47 ohm resistor R108 is placed in the ckt. for parasitic suppression.

g. In positions 1 through 6 of control head "A", the second frequency multiplier stage is inoperative, the cathode of V103 being open circuited by the actions of switch S115, and the plate ckt. being incomplete because the rotary switch S103 performs no useful function until after position 6.

h. On position 7 of control head "A" the second frequency multiplier becomes operative, and the plate tank is tuned with C115A and the slug in the inductance L106.

i. Note that the arm that is drawn at about "4 l'clock" on the blueprint representation of S103 is short, so short that its only function is to contact the circumferential bars of the switch. The arm of the switch that is drawn at "12 o'clock" is a long, couble contact arm, that shorts across from the circumferential bars to the switch contacts. As with S102, the two arms of the switch are tied together both mechanically and electrically, so that they work together at all times.

j. Position 13 of control head "A" is the Low Frequency position of the transmitter. Notice that position 13 of control head "A" corresponds to positions 14, 15, and 16 of switch S103, the three contacts being tied together, while the position 13 of S103 is blank.

1. In position 13, the swtich S114 is actuated by a cam on the control head shaft, thereby opening the cathode ckt. of the High Frequency Master Oscillator, the cathode ckt. of the first frequency multiplier, and completing the cathode ckt. of the Low Frequency Master Oscillator, as well as applying plus 28 volts for the operation of the Low Frequency relay K105, which changes over the necessary antenna ckts. for low frequency operations.

k. Note that the switch S103 in position 13 of control head "A" couples the output of the Low Frequency Master Oscillator to the signal input grid ckt. of the Power Amplifier tube.
l. Note that the two frequency multipliers have a common B plus plate supply. To avoid unwanted coupling between the two frequency multiplication stages an LC filter combination is employed, that filter being made up of C127, L115, and C131, which effectively isolates the plate signals of the two stages, and places the lower ends of the two associated tank ckts. at RF ground.

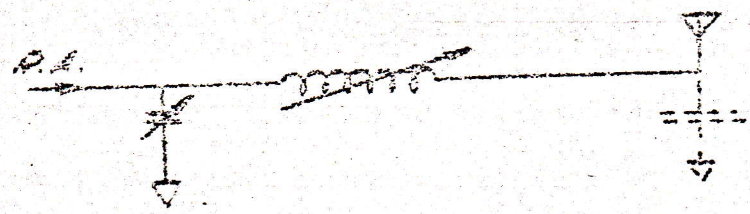
TUESDAY:

1. The Power Amplifier stage.
   a. The input signal to the Power Amplifier stage is coupled through the condenser C116 to the signal input grid of the 813 PA tube.
   b. The RF choke in the grid-to-ground ckt., L107, is used to maintain the grid at a high RF potential while still maintaining a relatively low DC resistance path from grid to ground.
   c. Class C bias is employed in the PA stage, that bias being furnished by the grid leak action of C116 and R110.
   d. The resistor R111 is used as a meter shunt when the meter M102 is being utilized as a grid current indicator during the tuning-up procedure.
   e. The resistor R112 in the screen dkt. of V104 is used as a parasitic suppressor.
   f. The screen of V104 returns to B plus, 400 volts, through R112, the 6-7 winding on the modulation transformer, section RB of the Power Level switch, and contacts 5 and 13 of the Keying Relay, K102.
   g. The plate load impedance of the PA stage is the RF choke, L108, for high frequency transmissions, and the combination of L108 and L109 for low frequency transmissions. Note that L109 is normally shorted out by the lowest section of the Low Frequency relay, K105, and L109 is actually a part of the ckt. only on low frequencies.
   h. The plate of V104 returns to B plus high voltage through L108, K105, and the 4-5 winding on the modulation transformer is shorted out during CW teansmissions by the action of the CW relay, K103, contacts 6 and 7.
   i. The screen of V104 is bypassed to prevent degeneration by the action of C119.
   j. The bottom of the plate load impudance of the PA is bypassed to ground by two series condensers, C120A and C120B. The two condensers in series are tied to the screen, which in turn is bypassed to ground by C119. The two condensers in series from the plate ckt. are so used because of possible **high voltage breakdown difficulties, not so much from the DC s** supply, but from audio voltages from the modulation stage.
   k. The output pulses from the PA tube are coupled through the condenser C118 to the antenna loading ckts., the "Pi" and "L" networks that make up the Collins antenna tuner.

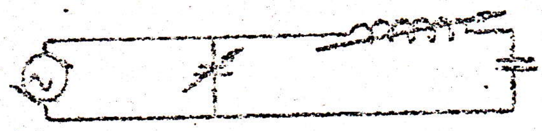
2. The Collins Antenna Tuner.
   a. In this type of antenna tuning and matching system, the antenna actually becomes an integral part of the tank ckt. of the Power Amplifier stage. Because of this, we tune the Antenna and the PA at one and the same time, always tuning for a dip in PA plate current.
   b. Note that control head "C" is the main variable element in the antenna ckts., controlling as it does numerous cam-operated and rotary type switches. Control "C" has scale numbers ranging from 1 through 13...these numbers do not correspond to the numbers on control head "A", so position 13 of control head "C" is the highest frequency position of the transmitter.
   c. In positions 1 through 7 of control head "C" it is assumed

that the antenna will always appear to be too short, ... rically, so an "L" type of feed system is employed, the basic ckt. being diagrammed below.

("L" feed)

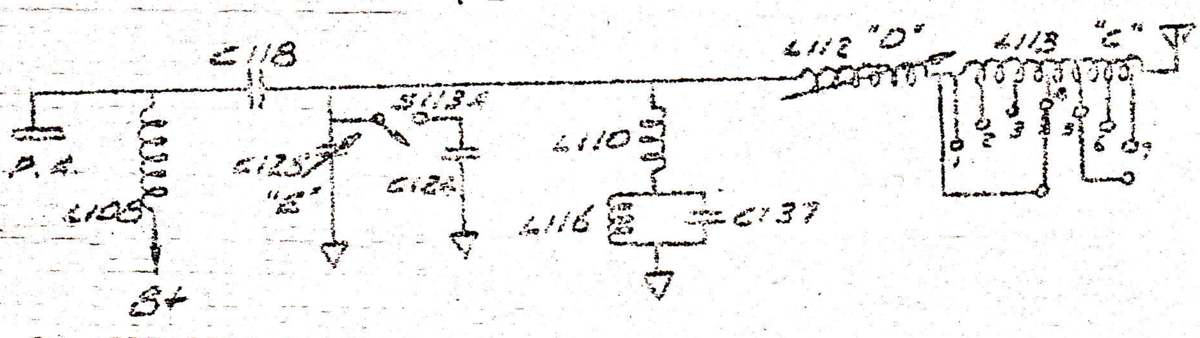


1. In the operation of this system it is convenient to visualize the antenna as a capacitance to ground. In this case we can arrive at the same ckt. as a "Pi " section LC tank, with the fixed capacity of the antenna as one leg, and the variable condenser in the tuning ckt. as the other leg, the whole tied across an RF generator.



2. The voltage developed across the inductance will be divided across the two capacitances, inversely as the ratio of their sized.
3. We load down the transmitter by reducing the size of the inductance, and then re-tuning to resonance with the variable condenser. This results in a lower impedance than we formerly had across the PA output, so more power will be absorbed from the PA plate ckt., resulting in greater circulating current in the antenna tuning system, and greater output from the antenna itself.
4. Therefore, to increase the loading on the transmitter with an "L" type feed system, we reduce the size of the series incudtance, and then retune the ckt. to resonance at out operating frequency by means of the variable condenser, which will necessarily have to be increased in size.
5. The "L" network utilized in the ATC has two inductances in series to the antenna, providing a coarse adjustment of inductance ty taps on L113, and a fine adjustment with the variometer L112.

("L" network ckt.)



6. The ckt. made up of L110, L116, and C137 has no bearing on the operation of the antenna tuner, because its resonance point is far removed from the operating frequencies of the ATC. The purpose of this ckt. is to provide a DC static drain path to ground from the antenna in the event of static electricity accumulation on the aircraft antenna.

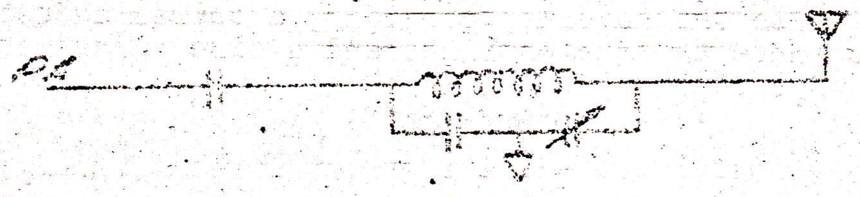
7. Notice that the variable condenser, control "E" is calibrated through 360 degrees of shaft rotation, indicating that we have capacitance variation through 360 degrees of shaft movement. This circumstance is brought about through the action of switch S113A, which is operated by the shaft of control "E" and is closed when control "E" reads 0-100, and open when the dial reads 200-100. S113-A throws the fixed condenser C124 in parallel with the variable condenser C125, and thus fixes the minimum capacity possible, which is slightly greater that the capacity of C124 when the dial reads 100. As the dial is rotated past 100, the switch S113A opens, leaving only the minimum capacity of C125 in the ckt., hence, the dial reading jumps to 200 and comes back down to 100 as the dial is turned through its entire range, and C125 comes closed once more.

8. The switches S113E, F, G, and H do not function during the time that the "L" network is being employed, nor does the feed change-over switch, S113B.

9. Note that on Position 7 of control head "C", and on through position 13, the inductance L113 is completely shorted out. Note also that in positions 7 through 13 there is an additional short from the fifth step to step number 7. The object of this additional short is to break up a parasitic tank ckt. formed by the inherent inductance and distributed capacity of the coil L113---otherwise, the parasitic tank would absorb power from the transmitted signal and reduce the carrier power accordingly.

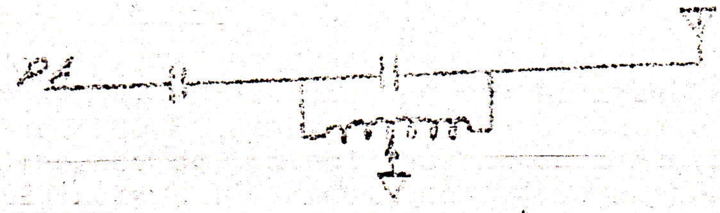
d. In positions 8 through 13 of control head "C" it is assumed that the antenna will probably be close to the correct length and will be a fairly high voltage point at the feeder contact. To feed this type of antenna, a "pi" network is employed, the basic ckt. being diagrammed below.

("Pi" feed)



1. In the operation of this system the antenna is considered as being in parallel with the output variable condenser, hence, any voltage appearing across that condenser will also be appearing across the antenna.

2. The grounded point between the two condensers will actually appear at some point along the inductance, because the two condensers are acting as a voltage divider across the inductance. By varying the sizes of the two condensers, that ground point may be made to move at will along the inductance.



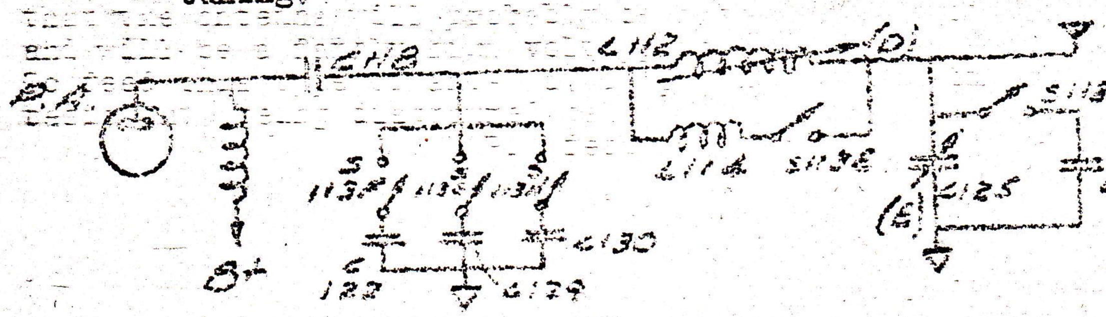
As the ground point on the inductance approaches the transmitter end of the inductance, the impedance between the transmitter and ground will decrease, thereby drawing more current from the PA and loading it down. This allows more carculating current in the antenna tuned ckts., with consequent greater radiation from the antenna itself.

3. In order to make the apparent ground point on the inductance move towards the transmitterk it is necessary that either the output condenser be made smaller in capacity, or the input condenser made larger in capacity. Since the smoothly variable element is usually the output condenser, that component is utilized for loading purposes, the coarse adjustment for loading being a tap switch arrangement that throws various amounts of lump capacity across the input to the antenna ckt.

4. Because changing the amount of capacity in the ckt. will obviously detune the system, it must be retuned with the variable inducanace.

5. Therefore, when using a "Pi" network for feeding the antenna, the loading is accomplished by varying the output condenser, increased loading being obtained as the condenser becomes smaller insize. Tuning of the system is a function of the variable inducaance.

6. In the "PI" network used in the ATC antenna tuning system, condenser C125 (control "C") is used for leading and the variable inductance L112 (control "D") is used for tuning.



7. The input condensers are C122, C129, and C130, and these condensers are used in various combinations by means of the switches S113F, G, and H. Those combinations are....

Control C	Input Capacity
8	175 mmfd.
9	100 mmfd.
10	50 mmfd.
11	25 mmfd.
12	stray ckt. capacity
13	50 mmfd.

8. Switch S113B changes over the antenna system from "L" to "Pi", and is drawn in the "L" position. It changes over to its alternate position from 8 through 13 of control "C".
9. Switch S113E operates on position 13, to reduce the antenna ckt. inductance by paralleling L114 with L112.
10. Switch S113C acts to keep the inductance L113 shorted out during the entire time the "Pi" network is being employed.
11. The static drain ckt., with L110, C137, and L116 remains in the ckt. at all times, both in the "L" and "Pi" networks, but performs no useful function other thamn that mentioned before.

3. The output from the antenna tuning system goes to the antenna through the vacuum switch, S118, which operates as part of the keying relay mechanical system. The object of having the contacts make-and-break in a vacuum is to prevent RF arcing at the relay contacts, with subsequent burning and destruction of those contacts.
   a. Note that the vacumm switch also transfers the antenna over to the rcvr. during the intervals when the transmitter is not being used.

4. The antenna current meter, M101, is inductively coupled to the antenna lead, and that coupling may be varied, As was the case with the GO-9, the antenna current meter means little, except that there will be an indication if it happens to fall near a high current point along the electrical length of the antenna. It is perfectly possible for the transmitter fo be functioning correctly even though there may be no indication on the antenna current meter.

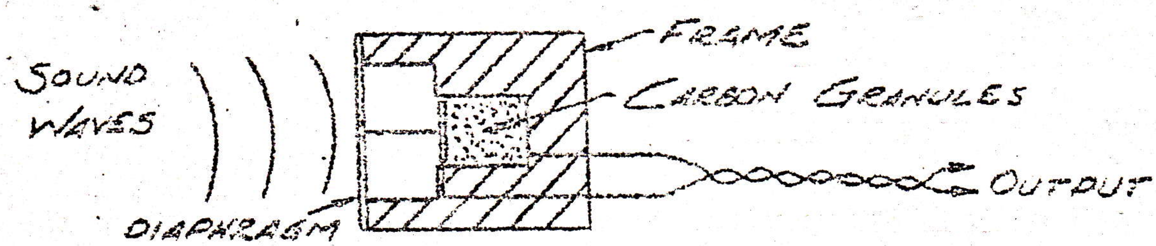
WEDNESDAY:

1. The microphone input ckts.

a. The ATC transmitter is so designed that VOICE emission is possible in addition to CW and MCW types of emission. When boice, or phone, transmission is employed, either one of two basic types of microphones may be employed, the "carbon"mike or the "dynamic" mike.

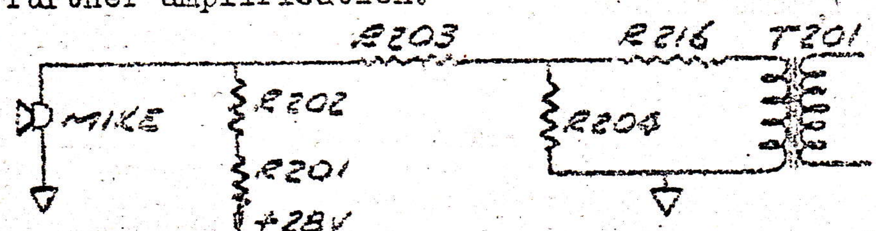
1. The carbon type of microphone operates as nothing more than a variable resistor, the resistance of which can be made to vary directly with the frequency and amplitude of the sound waves striking the device.

(carbon mike drawing)



(a) The carbon granules are rather loosely packed in the small metal box, called a "button", and resistance represented by the carbon granules from one side of the bottom to the other will vary inversely with the applied pressure. The applied pressuse will vary directly with the amplitude of the voice pressure waves impinging on the taut metal diaphragm, which is mechanically coupled to the moveable "wall" of the carbon button, and the repetition rate of these pressure changes will vary directly with the applied voice frequencies.

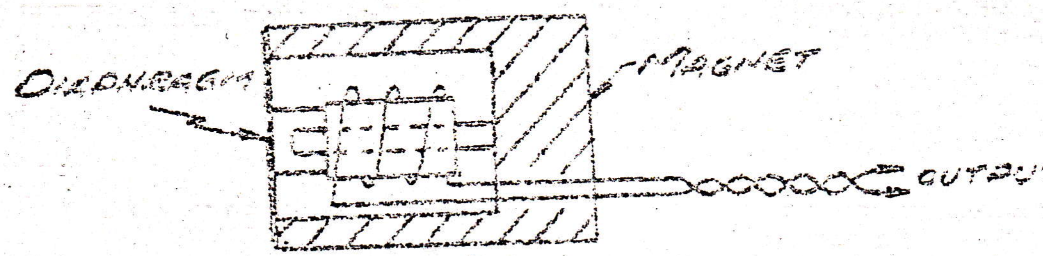
(b) As a ckt. component, the carbon mike is connected in series with a battery, or other DC current source, and the primary winding of a microphone transformer, which transfers the output from the carbon mike to the input signal grid of an audio amplifier tube for further amplification.



(c) In the static condition, there is a certain amount of current flow through the mike button and the transformer primary, occasioned by the battery E.M.F. When voice waves start striking the diaphragm of the mike, the resistance of the button will vary with those voice waves and consequently the current flow through the ckt. will be varied at an audio rate. These rapid variations in current will go through the mike transformer and drive the grid ckt. of the first audio tube , thus transforming the voice waves into electrical audio energy.

2. The dynamic type of mâcrophone operates on a different principle than the cargon mike, in that it is in itself a voice-powered generator, capable of delivering an AC current that will vary in frequency and amplitude directly as the voice sound waves actuating the device.

(dynamic mike drawing)

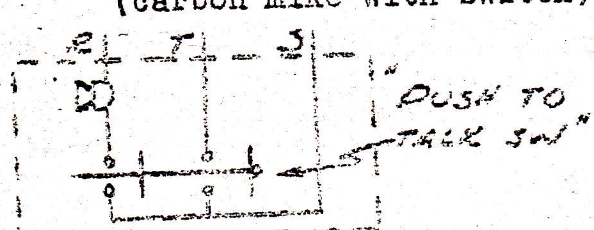


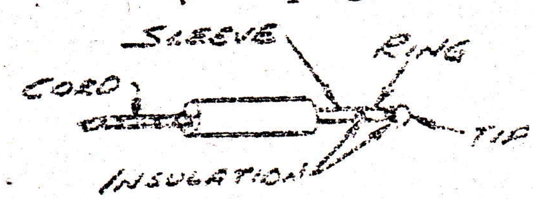
(a) The moving coil of the mike is fastened to the taut diaphragm through a mechanical linkage, and the coil is free to move exially along the "stem" of a muxhroon-shaped magnet, or an "E" shaped magget in cross section. As sound waves strike the taut diaphragm, causing portions of the coil windings to cut the magnetic lines of force existing around the magnet, thus inducing a voltage and current in the coil that will bear a direct relationship to the frequency and amplitûde of the origînal sound wave.

(b) The output from a dynamic mike is very low. As a ckt. component, the cynamic mike is coupled through an input mâcrophone transformer to the input grid of a very high gain audio amplifier. The output of the aadio amplifier stage is cascaded into other stages in order to raise the signal.

b. In addition to the audio signal device in the microphone container, there is also usually located a "push-to-talk" switch which is used to turn the transmitter on at the required times, and also to close the mike ckt. in the case of the carbon type mike. Because of the existence of this switching ckt. in most types of mikes, the lead from the mike to the transmitter will contain three contacts, and the cord plug will have three connections, called "ring", "tip", and "sleeve".

(carbon mike with switch) (mike plug)

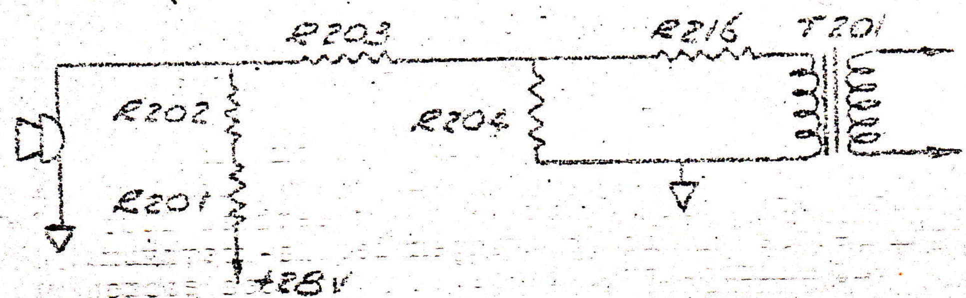




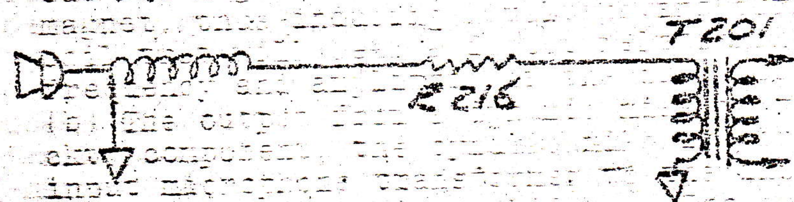
c. Also used is a throat mike, usually employed in small aircraft with but one crew member. This is a carbon mike in most cases, that is held against the larynx of the pilot with an elastic strap, leaving his hands free. This type of mike has no switch, so a separate one called a throttle switch is employed, and it

is mounted on one of the controls.
d. The output from a dynamic microphone is considerably less than the output from a carbon mike. Consequently, the mike input ckt. to the audio amplifier chain is designed to accomodate the weak signal from a dynamic mike, and when a carbon mike is employed its signal is reduced by means of suitable attenuating networks until it has about the same level as the full dynamic mike signal. Because of this design it is possible to employ the same Speech Amplifier stage for both types of microphones, where ordinarily this would not be possible.
c. It should be noticed that there is yet another possible signal source for the Speech Amplifier when transmitting, and that source is the MCW audio oscillator. The output from the MCW oscillator is so very weak that it is only slightly greater than the signal from a dynamic microphone.

(carbon mike input ckt.)



(dynamic mike input ckt.)



2. The speech amplifier.
a. The signal input to the audio channel is coupled through the microphone transformer, T201, to the signal input grid of the speech amplifier stage.
b. The speech amplifier stage utilizes a 12SJ7 in a high voltage gain, class 'A' stage.
c. Bias is provided by the combination of R207 and C202 in the cathode ckt.
d. R206 is a current bypass resistor, required because the filaments of V202 and V203 require more current than does V201.
e. The resistor shunting the secondary of the mike transformer is necessary in order to stabilize the input empedance of the tube. The admittance of a tube will vary with changes in frequency, thus reflecting a nonlinear impedance back to the microphone ckt., with resultant distortion. The resistor R205 shunts the transformer secondary and tends to reduce distortion.
f. C203 is the screen grid bypass condenser, and R208 is the screen grid voltage dropping resistor.
g. The condenser C205, from the plate of V201 to ground, is in the ckt. in order that unwanted high frequencies will be bypassed to ground. This is desirable, because most of the noise encountered in aircraft is in the higher audio frequencies.

and if those frequencies are not needed for communications then we can easily dispense with them. A frequency range of from 150 cycles to 3000 cycles is adequate for intelligible voice communication work..

h. R209 is the plate load resistor across which the output signal from the speech amplifier is developed. It ties to B plus, 190 volts, which is obtained from a voltage divider between plus 400 volts and ground. That voltage divider is shown on the blueprint immediately to the left of the MCW-CFI unit, and is made up of R117, R118, R119 all in parallel, the three in series with R120. R120 is bypassed with the capacitor C126 in order that the 190 volt line may be at RF ground, and AF ground.

3. The driver stage:

a. The output signal from the speech amplifier is coupled through C204 to the signal input grid of the audio driver stage, which uses a type 6V6 beam power tube.

b. The object of the driver stage is to obtain sufficient audio power to drive the modulator stage, which is a class 'B' stage utilizing push-pull 811's, which develop about sixty watts of audio power.

c. The driver stage operates class 'A', using cathode bias developed by the combination of R214 and C207.

d. The plate of the stage returns to B plus (190 volts) through the primary of the driver transformer, while the screen grid ties directly to B plus.

e. Notice that the driver transformer, T202, has a divided secondary that is tied to the grids of the modulator tubes. Remember that the modulator tubes are operating class 'B', so their grids will draw current during a portion of each audio cycle, and that current will flow through the two secondary windings of the driver transformer.....when the class 'B' modulator tubes draw grid current, then, it results in a lower impedance in the transformer, which in turn means that a reduced plate load impedance on the driver tube will appear. Any time a tube is working into a varying impedance, extreme distortion will result, due to non-linear conditions of operation. Therefore, the resistor, R203, is added to provide an inverse feedback ckt., feeding an out-of-phase voltage back to the grid, which will tend to stabilize the apparent load impedance of the stage and thereby minimize distortion caused by the non-linear impedance of the plate load ckt.

f. The output from the driver stage is also developed across the voltage divider ckt. of R212 and R211, after being coupled through C206. By means of this voltage divider ckt. a little more than 75% of the signal developed by the driver stage is used to operate the control grid ckt. of the sidetone amplifier, V203.

4. The side-tone amplifier.

a. The first basic thing to hold in mind is that the sidetone amplifier is operated as a zero gain stage, with the output from the driver stage as a reference.

b. The entire object of the sidetone amplifier is to couple the driver tube signal through to headphones, and to provide a means whereby variations in load impedance occasioned by different numbers of headsets or other audio devices will not affect the operation of the driver stage. In other words, the sidetone amplifier is an isolation stage, whose function is to provide coupling only.

c. The sidetone amplifier is operated class 'A', using cathode bias developed by R215. Notice that the cathode is left unbypassed, introducing degeneration to reduce the stage gain.

d. The plate and screen are returned to B plus, 190 volts.

e. T203 is the sidetone output transformer, which couples the sidetone signal through to the headphones. The secondary of the transformer has 8 taps provided, which run to a multitap selectof switch which acts as a sidetone volume control.

f. A high percentage inverse feedback ckt. is profided by the action of the condenser C208, which couples an out-of-phase voltage from the transformer secondary back to the cathode of V203, thus improving the quality of the signal and knocking down its strength considerable.

g. The sum total effect of all of the above noted degenerative methods, plus the fact that only about 75% of the signal developed by the driver stage is used to drive the sidetone amplifier, is that the output from the sidetone amplifier at maximum volume is just about equal to the signal developed by the driver stage.

5. The modulator stage.

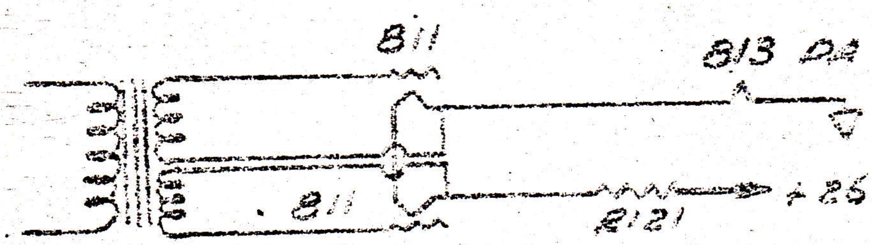
a. A couple of 811 type tubes are employed as push-pull modulators, operating class 'B' with a power delivery of approximately 60 watts of audio power.

b. The type 811 tube is primarily a class 'B' tube, and is very nearly cut-off with zero bias. However, in order to make it function true class 'B', we apply approximately -3.15 volts of bias to each tube, by retuning the frid windings on the driver transformer, T202, to the filaments of V105 and V106.

1. It must first be realized that the 811 tube does not have a cathode, but is instead a directly heated tube in which the electron stream originates from the filaments.

2. Bias in a directly heated tube is the actual voltage difference between the electrical center of the filament and the control grid. Since the filament voltage drop in an 811 tube is 613 volts, and the grid is retuned to one side of that filament, then the bias will be 3.15 volts.

(filament ckt.)



c. Notice that the Power Amplifier filament is in series with the filaments of the modulators, and they in turn are in series with R121 across the DC line.

d. The resistor R123 is a current bypass resistor in parallel with the filaments of the two 811's. That resistor is necessary because the 813 PA tube draws more current than the 811's could handle.

e. Plate voltage for the modulator tubes is 1150 volts, obtained through contacts 3,2,7, and 8 of the CW relay. Notice that when the CW relay is energized, as it must be for CW tansmission, the plate voltage is removed from the modulator tubes, making the stage inoperative.

f. The modulation transformer, T101, has two secondary winding, the 4-5 winding being in series with the plate voltage supply for the PA, and the 6-7 winding being in series with the screen voltage supply to the PA. A screen grid tube like an 813 cannot be successfully modulated by vaying plate voltage alone, but must also have the screen voltage modulated if any high modulation percentage is desired, due to the fact that the screen grid potential is a mian control of plate current in a screen grid tube.

f. When the ATC is transmitting with Voice, the modulation percentage will vary slightly with the amplitude of the sound waves striking the microphone, and the average percentage of modulation is approximately 80% with the emission selector switch in the Voice position.

g. Because it is possible for us to adequately control the level of the signal being generated by the MCW oscillator, we can modulate more heavily on the MCW setting. The modulation percentage on MCW runs up to 90% or better.

h. Notice that when the CW relay is energized we not only remove plate voltages from the modulator tubes, but we also short out the high voltage modulation winding on the transformer by the action of contacts 6 and 7 on the CW relay. When we are transmitting CW, we will obviously be making the plate current of the PA vary at the keying rate ----- these rapid surges of current in the 4-5 winding of the modulation transformer would indude a destructively high voltage in the other windings of the transformer, and either damage the transformer or the modulator tubes, so the 4-5 winding is shorted-out in the CW position to protect the transformer and the modulator tubes.

i. For a general review of modulation theory, refer to page 62 of this outline, which is included in the Third Week section.

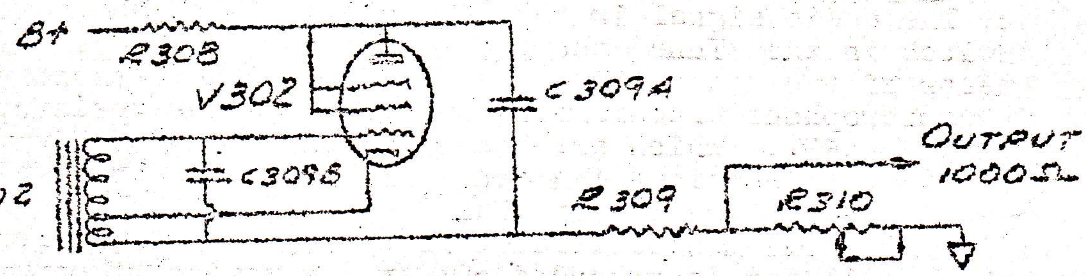
THURSDAY:

1. The MCW oscillator

a. For MCW emission, we key the exciter unit ckts. in the same fashion as for CW, with the single exception that we are modulating the power amplifier with a 1000 cycle tone at the same time, so the emitted signal will bear a 1000 cycle tone, or note.

b. The MCW oscillator generates the 1000 cycle tone that is used to modulate the PA. The MCW oscillator imploys a Hartley oscillator ckt., using a 12SJ7 tube that is triode connected.

(MCW oscillator ckt.)



c. The effective plate voltage applied to the tube is very low, a series dropping resistor of 220,000 ohms being in series with the 400 volt B plus lead to the plate of V302.

1. Notice that the B plus supply for the MCW oscillator is taken off the same 400 volt line that supplies the screen of the PA stage. Since the screen voltage of the PA is keyed by contacts 5 and 13 of the keying relay, then the MCW oscillator is keyed at the same time by the same keying contacts.

d. A triode connected 12SJ7 is very nearly cut-off with low plate voltage, so the MCW oscillator is operated with zero bias.. ....notice that there is no biasing ckt. in the MCW oscillator. The oscillator is operating very close to class 'B' under these conditions, and delivers very little power.

1. However, it must be bourne in mind that the output from the MCW oscillator is fed into the microphone transformer and the first Speech Amplifier stage, which was designed to handle the very weak signal from the dynamic microphone, so the MCW signal cannot be hardly any stronger than the signal from the dynamic mike.

e. The voltage appearing across the cathode-tap end of the oscillator tank ckt. appears across the two resistors, R309 and R310, Thenportion of the 1000 cycle signal developed across the rheostat R310 is used to drive the speech amplifier.R310, then, is the percentage modulation control for MCW operation and is usually adjusted for 90% modulation.

f. The MCW oscillator output goes out pin 7 of the Jones plug in the base of the MCW-CFI unit, through a shielded lead to contacts 5 and 6 of the Voice Relay, thence to section 'FC' of the Power Level Switch, and then to the microphone transformer, T201 ----- the above path is true for CW and MCW only, for Full Power Operation; that is, with the Power Level Switch in the 'Operate' position.

g. When the Power Level Switch is places in the 'Tune' position, the transmitter will still function as a low powered rig, something analogous to the 'Half-Power' setting in the GO-9 transmitter. This power reduction is effected by lowering the screen voltage to the PA by insertion of a screen voltage dropping resistor in the screen voltage supply line..... that resistor is R124, and it is thrown into the ckt. by means of section 'RB' of the Power Level Switch, in the 'tune' position.

1. Obviously, if we reduce the power of the transmitter by reducing the power of the PA stage, then we will also have to reduce the power of the modulation signal in order to keep from over-modulating.

2. The audio signal in the MCW setting, with the Power Level Switch in the 'Tune' position, is reduced in amplitude by means of two attenuating resistors applied in shunt with the microphone transformer primary......those resistors are R315 and R314, which are both in shunt with the MCW output when sedtions 'FA' and 'FB' of the Power Level Switch are in the #2, or 'Tune', position.

h. Notice that the MCW oscillator is never shut off. The signal from the oscillator is grounded out by the action of contacts 5 and 4 of the voice relay when 'Voice' transmission is employed.

i. When using the ATC for transmission of CW, the MCW oscillator continues to function, but the modulator tubes are dead, so no modulation results. Howeger, the 1000 cycle MCW tone is still being applied to the audio channel and it will be heard in the headphones through the sidetone amplifier stage for purposes of monitoring.

2. The CFI unit (Crystal Frequency Indicator)

a. The 84-1 CFI unit employs a 12SJ7 tube as a combination crystal oscillator and detector.

b. The cathode, #1 grid, and #2 grid elements are used in the crystal oscillator ckt., the #2 grid acting as the anode. The oscillator ckt. employs a crystal for frequency stability that is driving a tank ckt. of inherently low 'Q', achieved by the series resistor in the grid tank ckt.

c. As in the LM frequency meter, the 200 kc. oscillator 'gates' the tube electron stream, allowing the plate current to flow only in pulses determined by the crystal oscillator and its harmonics.

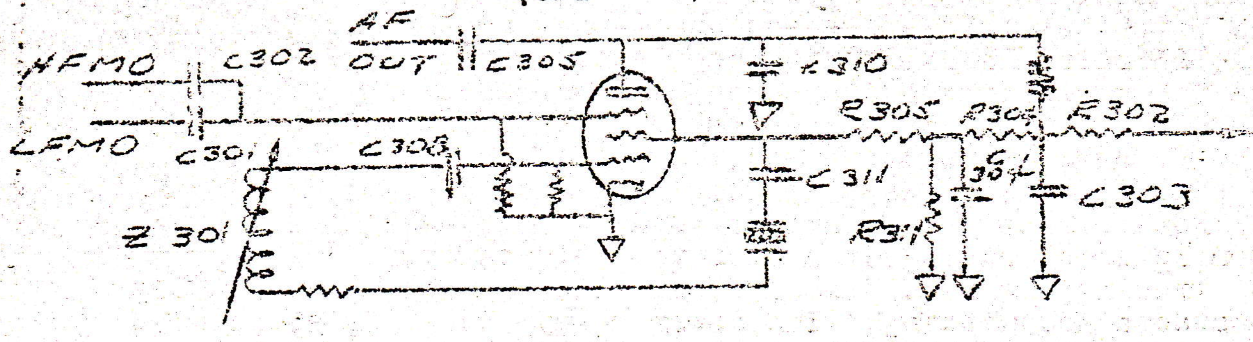
d. The signal to be checked is fed in on the suppressor grid of the tube, through either C302 or C301, where it beats against the crystal oscillator signals which provide 200 kc. check points.

e. After the master oscillator has been calibrated on a check point frequency, the moveable index onthe master oscillator control head ('B' or 'G') provides the necessary correction for closely adjacent frequencies to the check point.

f. The plate output of the stage is filtered by the condenser C310, so that only audio frequencies will appear in the output. The output from the CFI unit is fed into the audio channel through section 'FC' of the Power Level Switch, in the 'Calibrate' position, and then into the microphone transformer.

g. The audio signal from the CFI unit, when a crystal check point is being made, is heard in the headphones through the sidetone amplifier.

(CFI ckt.)



1. R305 is the osc. plate load
   C304 is a filter to keep sig. from pwr. supply
   R311, R304, and R302 form a voltage divider, bleeder
   R303 is the detector plate load
   R308, C307 provide osc. grid leak bias

h. Notice that the B plus supply for the CFI unit is obtained from section 'RA' of the Power Level Switch, on the 'calibrate' position of that switch. The same section of the Power Level Switch also removes the plate potentials from the multiplier stages in the 'Calibrate position'.

Operation of Switches and Relays

1. Turning equipment 'ON'
a. Note that the intire equipment operates on 28 volts, and that
the 28 volts comesinto the gear through the plug P502 located
on the schematic in the lower-left corner of the 416U-1 power
supply. The negative side of the line is grounded (pin 3 of
J502), and the positive side goes to K503 and K504, both thermal-
overload push-to-reset circuit breakers.
b. Notice that the dynamotor relay, K501, must be energized to
complete the ckt. from A plus to the dynamotor.
c. Tracing the lead from K503 we find that it runs to K502,
contacts and widding. The power relay, K502, is actuated by
section 'RB' of the emission selector switch, in any of its
three positions.
d. Actuation of the power relay allows plus 28 volts to be applied
to the autotune relay, K101, the filaments of the Xmtr., the
low frequency relay, K105, the voice relay, K104, and the CW
relay, K103. When the autotune relay, K101, is deenergized
and the S111 limit switch is in the proper position indicating
the completion of an autotune cycle, then plus 28 volts is also
applied to the power reduction relay, K505, the dynamotor relay,
K501, and the keying relay, K102. Placing a ground on the
opposite end of any one of the mentioned relays will actuate
that relay and compfete any of its associated ckts.
e. The dynamotor relay, K501, is actuated in several ways,
depending on what type of emission is desired.

CW---contacts 4 and 5 of the CW relay, K103
MCW----position 4, section 'RA' of the Emission Selector
switch, and section 'A' of the Local-Remote Switch.
VOICE--through contacts 1 and 2 of the Voice Relay, K104,
and thence through any of the four keying ckts.

The above notations assume that the Power Level Switch, S106,
is in either the 'Tune' of 'Operate' positions.
If the Power Level Switch is in the 'Calibrate ' position and
the emission selector switch is on 'Voice', then K501 is
actuated through contacts 1 and 2 of the Voice Relay and section
'FA' of the Power Level Switch. If the Emission Selector Switch
is in the CW position, then contacts 4 and 5 of the CW relay,
K103, complete the cynamotor relay ckt. to ground. If the
Emission Selector Switch is in the MCW position, then the
dynamoter relay ckt. is competed to ground through section
'RA' of the Emission Selector Switch and section 'A' of the
Local-Remote Switch. In any event, regardless of which type
of emission is selected, in the Calibrate position of the Power
Level switch the dynamotor will function at all times without
the necessity of the operator completing a keying ckt.-----
of course, the transmitter is not 'ON the air' during the
calibration period due to the fact that screen potential is
removed from the PA and B plus from the frequency multipliers
by sections 'RB' and 'RA' of the Power Level Switch in the
'Calibrate' position.

2. The Voice position, Pwr. Lev. Sw. in 'Operate'.
a. The Voice Relay, K104, is actuated by section 'RA' of the
Emission Selector Switch and section 'A' of the Local-Remote
switch.

b. Contacts 1 and 2 of the Voice Relay in series with any of the keying ckt. (regular key, mike push-to-talk button, throttle switch, or test key) completes the energization ckt. for the cynamotor relay, K501. Therefore, in the Voice position of the emission selector switch the synamotor will run only when one of the four keys is operated. Operation of any one of the keys will operate the keying relay, K102, at the same time and allow the transmitter to go 'on the air'.

c. Contacts 4 and 5 of the Voice relay will ground out the signal from the MCW oscillator.

d. The microphone signal will drive the speech equipment and thereby modulate the emitted carrier signal.

3. The Voice Position, Pwr. Lev. Sw. in 'Tune'.

a. All of the operation steps are the same as in the 'Operate' position of the Power Level Switch.

b. Because power output from the transmitter is drastically reduced in the 'Tune' position, because of the reduction of screen volvage to the PA by the action of section 'RB' of the Power Level Switch, it is obvious that there must as well be a reduction in the audio modulation power to prevent over-modulation. Notice that section 'FB' of the power level switch places R134 in shunt with the primary of the microphone transformer, thus reducing the amount of signal applied to the audio amplifier and reducing the modulation.

4. The CW position, Pwr. Lev. Sw. in 'Operate' or 'Tune'.

a. The CW relay is actuated by the Emission Selector Switch.

b. Contacts 4 and 5 of the CW relay actuate the dynamoter relay, so that the dynamotor runs continuously during CW transmission periods.

c. Contacts 2 and 3 of the CW relay remove the plate potential from the modulators, rendering them inoperative.

d. Contacts 6 and 7 of the CW relay short out the 4-5 winding on the modulation transformer, to prevent high keying currents to the plate of the PA from damaging the transformer or the modulator tubes.

e. Any one of the four keying methods may be used to actuate the transmitter, by controlling the Keying Relay.

f. Note that the MCW oscillator signal is still being applied to the audio amplifier, in order that the operator may be enabled to monitor his own keying through the sidetone ckt.

The MCW position, Pwr, Level Sw. in 'Operate'.

a. The emission selector switch and the Local-Remote switch actuate the Dynamotor Relay, K501, in the 'MCW' position of the ESS.

b. Because the CW relay is not actuated in the MCW position, the modulators are operative, so that each time the key is depressed by the opemtor, the Keying Relay puts the Xmtr. 'on the air' and the MCW oscillator modulates the carrier with a 1,000 cycle note. The operator hears the modulation tone each time the key is depressed, through the sidetone amplifier ckt

6. The MCW position, Pwr. Lev. Sw. in 'Tune'.

a. Same sequencg of operation as for 'Operate'.

b. In the tune position of the Power Level Switch, the PA power is reduced, so it becomes necessary to reduce the modulation power in order to keep from over-modulating. Notice that in the 'Tune' position, sections 'FA' and 'FB' are in such a position as to shunt the primary of the microphone transformer with two resistors, R134 and R135, thus reducing the amount of signal applied to the audio amplifier and reducing modulation.

c. Since we are modulating heavier in the MCW position than in the Voice position we have to reduce the MCW signal more in the Tune position that the Voice signal, hence the employment of the two resistors rather than only one as was the case with Voice modulation reduction.